ECONOMIC ANALYSIS OF DAM DECOMMISSIONING

March 2003

U.S. Department of the Interior
Bureau of Reclamation

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY ***(Leave Blank)***

2. REPORT DATE

March 2003

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

Economic Analysis of Dam Decommissioning

5. FUNDING NUMBERS

Fiscal year 2002-3 BOR Technical Service Center Manuals & Standards and Office of Policy Analysis General Planning Studies funds

6. AUTHOR(S)

Jonathan L. Platt
Economics Group
Technical Service Center
U. S. Bureau of Reclamation

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U. S. Bureau of Reclamation
Technical Service Center
Economics Group (D-8270)
Denver, Colorado 80225

8. PERFORMING ORGANIZATION REPORT NUMBER

EC-2003-01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U. S. Bureau of Reclamation
Denver, CO 80225

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

DIBR

11. SUPPLEMENTARY NOTES

n/a

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Available from the National Technical Information Service,
Operations Division, 5285 Port Royal Road, Springfield, Va 22161

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

This report describes the typical range of direct implementation cost, other direct cost (lost benefits), and benefit components, along with potential measurement methodologies, associated with economic benefit-cost analyses of dam decommissioning.

14. SUBJECT TERMS

Dam Decommissioning or Dam Removal, Benefit-Cost Analysis

15. NUMBER OF PAGES

61 pages

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

Technical Memorandum Number EC-2003-01

ECONOMIC ANALYSIS OF DAM DECOMMISSIONING

by

Jonathan L. Platt

Economics Group
Technical Service Center
Bureau of Reclamation
Denver, Colorado

March 2003

UNITED STATES DEPARTMENT OF INTERIOR BUREAU OF RECLAMATION

ACKNOWLEDGMENTS

This research was conducted under fiscal year 2002-3 U. S. Bureau of Reclamation Technical Service Center manuals and standards funding and Office of Policy Analysis general planning studies funding. The author would like to acknowledge Earl Ekstrand, Steven Piper, Randy Christopherson, Bob Hamilton, and various other members of the Reclamation Technical Service Center economics group for their technical advice.

TABLE OF CONTENTS

Page #

1.0 Introduction.. 1

2.0 Economic Theory of Dam Decommissioning.. 5

3.0 Categories of Impact.. 11

3.1 Direct Implementation Costs.. 14

3.1.1 Land and Facilities Acquisition.. 14
3.1.2 Dam Removal.. 15
3.1.3 Sediment Removal.. 16
3.1.4 Site Stabilization and Restoration... 17
3.1.5 Operations and Maintenance... 17
3.1.6 Water Rights... 18

3.2 Other Direct Costs and Benefits.. 19

3.2.1 Market Based Other Direct Costs or Benefits....................... 21

3.2.1.1 Fisheries.. 21
3.2.1.2 Agriculture.. 29
3.2.1.3 Municipal and Industrial.. 32
3.2.1.4 Hydropower.. 36
3.2.1.5 Navigation.. 39
3.2.1.6 Flood Control.. 41
3.2.1.7 Land Use/Property Values...................................... 43

3.2.2 Non-Market Based Other Direct Costs or Benefits................ 45

3.2.2.1 Recreation.. 45
3.2.2.2 Nonuse Values... 50

3.3 Hypothetical Dam Removal Example.. 53

4.0 Summary & Conclusions.. 57

5.0 Bibliography..
59

LIST OF TABLES

		Page #
Table 1	Typical Incremental Benefit-Cost Effect for Dam Decommissioning and Dam Commissioning Analyses	13
Table 2	Typically Applied Benefit-Cost Analysis Measurement Approaches	20
Table 3	Benefit-Cost Analysis of Hypothetical Dam Removal Example	56

LIST OF ACRONYMS

BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
CBO	U. S. Congressional Budget Office
CEO	U. S. Council of Environmental Quality
Corps	U. S. Army Corps of Engineers
CV	Contingent Valuation
ERS	U. S. Economics Research Service
EIS	Environmental Impact Statement
EQ	Environmental Quality
ESA	Endangered Species Act
FERC	U. S. Federal Energy Regulatory Commission
GAO	U. S. General Accounting Office
M&I	Municipal and Industrial
NED	National Economic Development
NEPA	National Environmental Policy Act
NPV	Net Present Value
O&M	Operations and Maintenance
OMB	U. S. Office of Management and Budget
OSE	Other Social Effects
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
Reclamation	U. S. Bureau of Reclamation
RED	Regional Economic Development
T&E	Threatened and Endangered
TC	Travel Cost
WTA	Willingness-to-Accept
WTP	Willingness-to-Pay

1.0 INTRODUCTION

The objectives of federal water agencies in the United States, such as the Army Corps of Engineers (Corps) and Bureau of Reclamation (Reclamation), have evolved over time. These agencies were initially tasked with the water development role of building dams to expand navigable waters, control floods, and develop water supplies to encourage economic development. Today, since many of the best sites from an engineering standpoint have already been dammed and unappropriated water supplies are becoming increasingly scarce, the focus of these agencies has expanded to include water management. Allocating limited water supplies between competing uses, including environmental demands, has become an important objective of these agencies.

With the signing of the National Environmental Policy Act (NEPA) of 1969, federal agencies are required to complete environmental reviews of their proposed actions. Prior to that time, most federal water development studies focused primarily on the extractive or consumptive uses of the water. In the spirit of NEPA, more recent studies have attempted to give equal consideration to all resource demands, both consumptive and nonconsumptive. As a result, environmental issues now play a much more important role in federal decision making compared to 30 years ago.

Dam decommissioning and dam removal have begun to surface as environmentally attractive alternatives in federal water management studies, particularly those with significant fisheries components. On the Elwha River of the Olympic Peninsula of Washington State, a 1995 environmental impact statement (DOI, NPS, 1995) suggested the removal of both the Elwha and Glines Canyon Dams to restore salmon and steelhead. On the lower Snake River in eastern Washington, consideration was given to breaching four Corps dams to help restore several species of endangered salmon (Loomis, 2002). On the Colorado River, environmental groups have proposed the removal of Reclamation dams including Glen Canyon and Flaming Gorge to aid recovery of four endangered species of resident fish. Numerous privately owned and operated dams have also been scrutinized for possible removal. In 1996, Newport Dam #11 was removed from the Clyde River in Vermont marking the first time the Federal Energy Regulatory Commission (FERC) recommended removing a dam for environmental reasons. In 1999, Edwards Dam on the Kennebec River in Maine was removed after FERC ruled against the owner's application for license extension for the first time.

As more fish species are listed as threatened and endangered (T&E) under the Endangered Species Act (ESA), and dams are targeted as impediments to recovery, calls for dam removal will likely increase. Significant effort and financial resources have been devoted to try and improve fish passage, restore river habitat, and limit fish mortality through structural improvements to dams (e.g., constructing fish ladders, screens, temperature control devices), changes in reservoir operations (e.g., providing reservoir releases which match historic flow patterns, collecting and barging fish), habitat improvements (e.g., increasing flows, adding side channels and meanders, instituting land management practices), mortality reduction (e.g., controlling predators, limiting commercial, sport, and tribal harvest), and population augmentation (e.g., initiating hatcheries programs).

Despite all these efforts, many fish populations continue to decline. In some areas, certain sub-species have been declared extinct. To reverse this trend, many conservationists believe that extraordinary efforts are required, suggesting that the only way to truly restore these fish populations may be to return the ecosystems to a more natural, less managed state through dam removal. Their implicit assumption is that the general public would consider the return of these rivers to a free flowing state, along with the potential recovery of T&E species, to be quite valuable even if they never intend to visit them. Estimation of these nonuse or passive use values are often required to justify dam removal. These values will be discussed later in the report.

In addition to the environmental community, commercial, sport, and tribal fishers are also often supporters of dam removal. This is particularly true of river systems with anadromous or other migratory fish, where dams have obstructed natural migrations contributing to diminished fish populations. In many cases, Indian tribes have a unique interest in dam removal. The right to fish has been identified as a tribal trust asset whereby the federal government has a legal obligation to manage fisheries in trust for the tribes. A tribe may be allocated a significant share of a river system's allowable harvest for commercial, subsistence, and ceremonial purposes. From a recreation perspective, anglers may be supportive of dam removal given the potential for increased in-river fish populations. While most in-river native fish populations would likely increase with dam removal, resident reservoir fisheries would typically be lost. Furthermore, in certain naturally warm water river systems, such as the Colorado River, dams have created concentrated cold water habitat immediately downstream of the dam. Despite being unnatural, these habitats have been stocked with trout, creating extremely valuable "blue ribbon" sport fisheries. Finally, rafters and kayakers may also be interested in dam removal as an option to extend boating runs and increase seasonal instream flows.

The aging of structures may also result in proposals for dam removal. In the U.S., many dams were constructed in the early to mid-1900s. As dams age, maintenance and repair costs can be expected to increase substantially making future investments questionable. Older dams may become less functional as sediment accumulates and displaces the amount of water which can be stored in the reservoir. In addition, at some point, ordinary repair and maintenance may no longer be able to maintain the required structural stability of the dam, increasing the potential for dam failure and associated losses in property damage and possibly human life. For privately owned dams, such situations may result in substantial increases in the costs of liability insurance. Instead of expending large sums of money to repair these facilities, it may make economic sense to remove the structure. As dams are determined to be unsafe based upon inspection, or come up for licensing renewal, proposals for dam removal will undoubtedly increase.

The foregoing discussion has highlighted some of the incentives for dam decommissioning and removal, based on potential beneficial effects. Of course, there can be very significant disincentives to dam decommissioning, primarily related to losses which would be incurred by existing water users. The purpose of this document is to lay out an objective analytical framework in which beneficial and adverse effects are compared.

This report presents discussions from the national perspective (as opposed to regional, local, or individual perspectives) which is typically the primary focus of analyses prepared by economists with water agencies of the federal government. The paper therefore applies primarily to dam removal studies where the facilities are owned and operated by the federal government, but is also applicable to studies of privately owned facilities.

2.0 ECONOMIC THEORY OF DAM DECOMMISSIONING

The discipline of economics is oriented toward addressing problems of resource scarcity and the inherent need to allocate limited resources among competing demands. This emphasis on providing information to aid in tradeoff analysis, where selecting one option implies that another must be forgone, fits well within the context of federal decision making.

Since 1983, federal water agencies have applied the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) when considering the feasibility of commissioning a new dam. Logically, these same P&Gs would be followed when considering the feasibility of decommissioning a dam. As expressed in the P&Gs, federal water agencies are mandated to consider the effects of their actions on the nation as a whole, but also typically take into consideration the influences of their actions on the economies of local communities. The national perspective is provided through conducting national economic development (NED) oriented benefit-cost analyses and the local perspective through regional economic development (RED) impact analyses. The combination of these two approaches provides a comprehensive view of the economic effects of a federal action.

In addition to the NED and RED analyses, the P&Gs also require consideration of environmental quality (EQ) and other social effects (OSE). The EQ account attempts to present non-monetary effects on significant natural/ecological, cultural, and aesthetic resources.[1] The OSE account basically covers all effects upon the human environment not covered by NED and RED, such as environmental justice impacts on low income or minority populations in terms of distribution of benefits, human displacement, etc. The consideration of basic human rights and risks from an international perspective has come to the forefront of dam evaluations (World Commission on Dams, 2000). These four accounts should be given equal weight and cover the range of effects upon the natural and human environments as required by NEPA.

This linkage to NEPA and the preparation of environmental impact statements (EIS) is interesting, particularly with respect to benefit-cost analyses. Generally speaking, while it is standard practice to include a regional economic analysis in an EIS, it is fairly rare to find NED type benefit-cost analyses. According to the Council of Environmental Quality (CEQ) regulations (40 CFR 1502.23), "for purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations." Therefore, an EIS is not required to contain benefit-cost analysis. Despite this setting, it is likely

---

[1] Environmental effects, such as water quality, can be evaluated indirectly within an economic analysis. For example, water quality changes can have repercussions within certain economic categories. Water quality can affect the following: fisheries analysis (through the impact of fish populations), municipal and industrial analysis (through changes in the costs of treatment), agricultural analysis (through changes in cropping patterns and yields), recreation analysis (through changes in access due to health issues for water based activities), etc.

that a benefit-cost analysis would be required for dam removal proposals as it is for dam construction proposals. Since NED benefit-cost analyses often provide the framework for subsequent RED analyses, the focus of this report will be on the benefit-cost comparisons. For discussion of RED analysis from a federal perspective, see Piper (2000).

Nationwide Perspective - NED based Benefit-Cost Analysis (BCA):

According to the P&Gs, BCA attempts to estimate the present value of net national benefits associated with each proposed action. In a procedure referred to as "with" and "without" analysis, net benefits of each proposed action are compared to net benefits of the no action or baseline alternative to determine if societal welfare improves.[2] BCA assumes an action increases national welfare when the present value of benefits exceed the present value of the costs, otherwise referred to as a positive net present value (NPV). This situation is analogous to a benefit-cost ratio (BCR), present value of benefits divided by the present value of the costs, in excess of one. Based on economic theory, unambiguous improvements in societal welfare occur only under a Pareto optimal setting where portions of society are made better off without hurting any other societal segment. Net benefit concepts are based on the Pareto compensation principal where society is considered better off when the winners could theoretically compensate the losers and still be better off.

The objective of this document is to describe economic benefit-cost analyses as opposed to financial analyses. Financial analyses concentrate exclusively upon the long-term inflow and outflow of funds from the perspective of the property owner. The standard assumption of this report is that the federal government owns the facilities. While a financial analysis could be developed from a federal perspective (i.e., focusing on the flow of funds to and from the U. S. Treasury), that is not the intent of the report. Economic analyses differ from financial analyses by considering the full range of potentially affected benefits and costs to society, regardless of whether or not dollars are actually transferred. Financial analyses determine if the project is profitable for the owner, whereas economic analyses determine if the project enhances welfare or well-being to society as a whole.

If both the no action/baseline and action alternatives result in positive net benefits, the selected alternative would be the one with the greatest net benefits since the two alternatives are mutually exclusive. Another way to obtain the same result would be to measure the change in benefits and costs of the action alternative compared to the no action/baseline alternative. If the change in action alternative benefits (incremental benefits) is greater than the change in action alternative costs (incremental costs), the action alternative would be selected and vice versa. This incremental analysis in essence combines the action and no action/baseline alternative

---

[2] The terms No Action Alternative and Baseline Alternative are used interchangeably. Both terms refer to the most likely future condition assuming the proposed "Action" Alternative is not implemented. Contrary to the implication of doing nothing (i.e., no action), the concept includes future actions which would be implemented without the action alternative.

analyses into a single perspective. Since the benefits and costs for both alternatives must be estimated at least to some extent before being commingled in an incremental analysis, the incremental approach becomes mainly a display issue. For example, assume that the no action/baseline alternative requires a significant dam renovation. An incremental analysis of dam removal would include the costs of dam removal as a direct cost and the costs of no action/baseline alternative dam renovation as an avoided cost benefit. The direct cost plus the avoided cost benefit results in the same incremental cost or benefit as would result if the two alternatives were analyzed and presented separately. The incremental analysis approach will be followed in the remainder of the document since it allows for a more concise discussion of the issues.

The objective of a BCA is to estimate, in monetary terms, changes in the discounted aggregated benefits as measured by the value of potentially impacted output of both market and nonmarket goods and services produced nationwide for comparison to the discounted total cost of implementing the proposed action. The general measurement standard for valuing benefits associated with the production of goods and services is represented by society's net willingness to pay (WTP) for each increment in output.[3] These net benefits are measured for both consumers and producers in terms of consumer surplus (maximum WTP minus purchase cost) and producer surplus (profit, or revenue minus cost of production).

From an overall perspective, BCA is simply a procedure for organizing and displaying information on both the positive and negative aspects of a proposed action. The difficulty obviously pertains to the actual estimation of the benefits and costs. The primary advantage of BCA is that it attempts to measure as many effects of an action as possible in common units, being that of current dollars. Given in many, perhaps most cases, certain effects may not be fully quantifiable in dollar terms, BCA can still be used to display results, but perhaps not completely in common units. The significance of the non-quantified or non-monetized elements will influence the comprehensiveness of the economic portion of the BCA (e.g., the NPV or BCR). Therefore, the economic portion of a BCA should be used as an aid to decision making and not a final decision tool.

An important element of a nationwide analysis is the consideration of substitution or displacement effects. If the primary affected area experiences a gain in certain benefits, but at the same time, an equal amount of those same benefits are lost elsewhere in the nation, then from a national perspective, the result would be no change in national benefits. In this case, gains are displaced by losses implying that from a national perspective, the benefits simply transferred

---

[3] An alternative, but theoretically equally acceptable concept is that of willingness-to-accept (WTA) payment. Typically, WTA would apply to situations where the general public incurs a loss in benefits. WTA assumes the general public owns the property right to the resource whereas WTP assumes the property right is held privately. While there are many resources which could be claimed to be held by the public, the normal procedure is to apply WTP since it can be revealed by markets or market-like settings.

from one region of the nation to another. In virtually every area of benefit measurement, the consideration of substitution effects can be critical to the NED analysis. If gains or losses in the various categories of output are deemed small enough so as not to affect prices and production elsewhere in the nation, then substitution effects could be considered minimal.

Selecting an appropriate period of analysis is also important in a BCA. The period of analysis reflects the sequence of years across which impacts will need to be estimated. This period should be long enough so as to include the majority of the anticipated impacts over time.

Another important aspect of conducting a BCA is discounting, or the conversion of benefits and costs incurred in different years to a comparable present value estimate. This present value conversion is accomplished using an interest factor called the discount rate. Benefits and costs expected in the future are discounted to the present. The larger the discount rate, the smaller the present value. While the basic idea is well accepted that the value of a dollar received in the future is less than the value of a dollar received today (assuming one could invest and earn interest on the dollar received today), applying this concept to future benefits in particular is still somewhat controversial. Some would claim that the value of future benefits shouldn't be discounted at all. The problem arises since after a certain time period, future benefits become essentially worthless. The larger the discount rate, the sooner the future benefits approach zero (e.g., at a 10% discount rate, the present value shrinks to less than 10% of the original estimated value by year 25 and less than 1% by year 50). Use of larger discount rates makes it difficult to accept projects with long-term inter-generational benefits relative to near term costs.

Federal water management agencies are mandated by the U. S. Office of Management and Budget (OMB) to apply discount rates as estimated by the Department of the Treasury. For example, the current fiscal year 2003 plan formulation and evaluation rate is 5.875%. In some instances, studies have applied a range a interest rates to presumably address issues of valuing long-term benefits and costs.

Given the complexities and uncertainty associated with estimating project benefits and costs, it is often useful to conduct sensitivity analysis on the results. Sensitivity analysis, as the name implies, attempts to determine how sensitive the results are to each of the underlying benefit and cost estimates, or other assumptions inherent to the analysis. The approach increases or decreases each benefit or cost estimate until the decision criteria (NPV, BCR, etc.) reverse. If the analyst is confident that the actual benefit or cost value falls within the sensitivity range associated with a given decision criteria result, then they would have confidence in the overall results of the benefit-cost analysis. Of course, sensitivity results become more complex if one starts looking at more than one factor simultaneously.

Another option in dealing with uncertainty is to assign probabilities to the estimated benefits and costs. Applying the probabilities to the initially estimated impact figures converts the results to expected values. A range (e.g., high, medium, and low) of benefit and cost estimates for each category could be used to provide a range of potential outcomes from worst case to best case. Alternatively, the range of benefits and costs by category could be multiplied by their associated probabilities to come up with an overall expected value for each impact category. Perhaps the most difficult part of this analysis is the assignment of the probabilities to each benefit and cost estimate.

3.0 CATEGORIES OF IMPACT

The previous section describes the types of economic analyses relevant to a study of dam removal without getting into details as to the typically experienced impact areas. This section presents some of the standard types of impacts one might incur when developing a dam removal BCA. For purposes of this discussion, “direct costs” are separated into two general categories, “direct implementation costs” and “other direct costs”. Direct implementation costs refer to expenditures incurred in the dam removal process for such activities as dismantling the dam and restoring the river. Other direct costs refer to the forgone project outputs or services associated with dam removal such as lost agricultural or hydropower benefits. Both categories of direct costs have a negative influence on the benefit-cost comparison. “Benefits” reflect positive impacts of pursuing an action. In the case of dam removal, in-river fisheries and related recreational and commercial harvests and value are typically expected to improve. Another benefit category reflects the costs avoided when pursuing dam removal, such as the no action/baseline alternative costs of dam rehabilitation. Since we are combining both the dam removal action alternative and the keep dam no action/baseline alternative into a single incremental analysis, it is important to include both the lost benefits and avoided costs of the without project no action/baseline condition. Finally, this section also describes BCA measurement methodologies for each category of impact except direct implementation costs. Given benefits and other direct costs can often be estimated using the same market or nonmarket based measurement approaches, they are presented in the same subsection.

Theoretically, the types of analyses associated with commissioning a dam should mirror those involved in decommissioning a dam. For the most part, P&G analyses would apply in either case. As noted previously, dam commissioning analyses conducted prior to NEPA and the P&Gs, could vary substantially from dam commissioning analyses conducted after implementation of NEPA and the P&Gs. By the same logic, dam decommissioning analyses based on NEPA and the P&Gs, could also vary substantially from the original dam commissioning analyses which were not based on NEPA and the P&Gs. Even if the commissioning and decommissioning analyses followed the same general logic and assumptions, the categories of impact may vary between the two analyses to the extent that circumstances can change over time. Certain impact categories may become increasingly or decreasingly relevant with time. For example, in the early 1900's, recreation was much less prevalent compared to today and as a result may not have been evaluated in some of the early dam justifications. Conversely, recreation is currently often a significant benefit associated with the presence of a dam. Similarly, for some projects, urban water use has increased dramatically from dams originally constructed primarily for agricultural purposes. So while the theoretical foundation of the analyses for dam commissioning and decommissioning may be similar, the actual components of the analyses may change over time.

Table 1 presents the range of potential BCA impacts for both dam decommissioning/removal and dam commissioning/construction analyses. For both analyses, note the three separate columns depicting the general categories of costs and benefits (i.e., direct implementation costs, other direct costs, and benefits or avoided costs). The far left column, entitled “Impact Category”, shows the range of issues often involved in a dam decommissioning or commissioning analysis. Following each impact category across the row indicates how that cost or benefit category comes into play within each analysis. By way of convention, two concepts separated by an “or” reflect the action alternative and no action alternative respectively (e.g., under dam decommissioning, dam removal represents the action alternative and dam rehabilitation the no action alternative). Concepts preceeded with a “DC:” separates a dam decommissioning concept from a dam commissioning (DC) concept (e.g., “dam removal and dam rehabilitation” relate to the action and no action alternatives for dam decommissioning, whereas “dam construction” relates to the action alternative under dam commissioning). When only a single concept is indicated (e.g., land acquisition, sediment removal, and the benefit categories from fisheries to nonuse preservation values), the concept covers all alternatives under both analyses.

As mentioned above, the analyses are similar, but not exact opposites. As a result, the impact categories may not apply to both analyses (e.g., land acquisition applies only to dam commissioning). In looking at the dam decommissioning portion of Table 1, note that many of the impact categories shown both a (U) and an (Y). This is because this impact category is likely to apply both under the “with project”/action alternative and the “without project”/no action alternative. The (U) represents the “with project”/action alternative and the (Y) represents the “without project”/no action alternative. As indicated in the table, under dam decommissioning, the “with project”/action alternative reflects the “remove dam” scenario, and the “without project”/no action alternative reflects the “keep dam” scenario. Under dam commissioning, the “with project”/action alternative represents the “construct dam” scenario, and the “without project”/no action alternative represents the “do not construct dam” scenario.

The positive and negative effects for the same impact category emphasizes the need to consider both the action and no action alternatives. Only by considering both alternatives can the net effect be estimated. For dam decommissioning, under the “remove dam” action alternative direct implementation cost categories (see U in column 1), the analyst may also have to consider avoided costs (see Y in column 3) associated with the “keep dam” no action alternative. Similarly, under the “remove dam” action alternative benefit categories (see U in column 3), one would also need to consider the other direct costs/lost benefits (see Y in column 2) associated with the “keep dam” no action alternative. From the dam removal perspective, the avoided costs and lost benefits simply reflect the costs and benefits of the “keep dam” no action alternative. The reverse is true for the dam commissioning analysis. Finally, a fourth column under both the dam decommissioning and dam commissioning analyses shows the direction of the typical net effect, either positive or negative, when combining the “with” project/action alternative and “without” project/no action alternative results. In a couple of cases, the direction of the net effect is normally unknown and was therefore shown with a question mark. While this table sounds complex, it simply boils down to considering both the action and no action alternative effects within the context of a combined incremental analysis. Reading the pertinent sections of the paper for each impact category along with the hypothetical example in section 3.3 should help clarify the table.

Table 1: Typical Incremental Benefit-Cost Effect for Dam Decommissioning and Dam Commissioning Analyses

Impact Category		Dam Decommissioning (DD) Analyses				Dam Commissioning (DC) Analyses			
Key: (U = with project effect, Y = without project effect) Dam Decommissioning (DD): U = remove dam, Y = keep dam Dam Commissioning (DC): U = build dam, Y = don't build dam	See Paper Section	(1) Direct Implementation Costs (-)	(2) Other Direct Costs (Lost Benefits) (-)	(3) Benefits or Avoided Costs (+)	(4) Typical Net Effect (+ or -)	(5) Direct Implementation Costs (-)	(6) Other Direct Costs (Lost Benefits) (-)	(7) Benefits or Avoided Costs (+)	(8) Typical Net Effect (+ or -)
Land and Facilities Acquisition	3.1.1	n/a			n/a	U			–
Dam Removal <u>or</u> Dam Rehabilitation / DC: Dam Construction	3.1.2	U		Y	?	U			–
Sediment Removal	3.1.3	U			–	n/a			n/a
Site Restoration <u>or</u> Habitat Improvement / DC: Site Preparation	3.1.4	U		Y	–	U			–
Site Maintenance <u>or</u> Dam Operations and Maintenance	3.1.5	U		Y	+	U			–
Water Rights Purchases	3.1.6	n/a			n/a	U			–
Fisheries: 1. Commercial Fishing	3.2.1.1		Y	U	+		Y	U	–
2. Tribal Fishing: - Commercial Harvest:			Y	U	+		Y	U	–
- Subsistence Harvest:			Y	U	+		Y	U	–
- Recreational Harvest:			Y	U	+		Y	U	–
Agriculture	3.2.1.2		Y	U	–		Y	U	+
Municipal & Industrial	3.2.1.3		Y	U	–		Y	U	+
Hydropower	3.2.1.4		Y	U *	–		Y *	U	+
Navigation	3.2.1.5		Y	U *	–		Y *	U	+
Flood Control	3.2.1.6		Y	U *	–		Y *	U	+
Land Use of Inundated Area	3.2.1.7			U	+		Y		–
Recreation	3.2.2.1		Y	U	?		Y	U	?
Nonuse Preservation Values	3.2.2.2			U	+		Y		–

* Dam removal would likely eliminate hydropower, navigation, and flood control. However, alternative sources of power, transit, and flood control should be considered. Similarly, dam construction would likely generate hydropower, navigation, and flood control. However, existing sources of power, transit, and flood control should be considered.

When evaluating effects for each impact category, the analyst needs to keep in mind that many of these impacts would involve off-site implications. While most of the construction aspects would be primarily experienced on-site, many of the effects on project benefits would occur off-site. As a result, a basin wide or even broader perspective may be necessary to fully evaluate impacts. To accomplish this, a thorough evaluation of the range of potential upstream and downstream consequences needs to be developed prior to beginning the analysis. In addition to the basin wide effects, if changes in project benefits are significant enough, they may have implications elsewhere in the region, state, or nation. Accounting for potential substitution effects may also be an important component of the analysis.

With certain categories of impact discussed below, a distinction has been made between full and partial dam removal when deemed important to the analysis. Full removal implies elimination of the dam and all associated structures whereas partial removal implies the dam is not completely removed as in the case of a breach or lowering. As a result, under a partial removal, associated facilities may remain intact. These two alternatives are often compared to a no action/baseline alternative of leaving the dam and associated structures completely in place and functioning. Of course, the no action/baseline alternative generally involves substantial costs as well, especially if the reason for the dam removal study relates to the aging of the structures.

While every study is unique, implying one set of guidelines or methods cannot possibly cover all situations, the following sections reflect some of the more common issues which typically arise within an analysis of dam removal.

3.1 **DIRECT IMPLEMENTATION COSTS**:

Direct implementation costs refer exclusively to the out-of-pocket expenditures related to dismantling the dam and restoring the river. As noted above, direct costs have a negative influence on the benefit-cost comparison. Most of the direct implementation costs are one-time up-front costs, but certain costs are incurred annually. Costs which are incurred after the initial year of the project planning period would need to be discounted back to year one (i.e., converted to present value). As noted in Table 1, this section includes both the direct implementation costs for the dam removal action alternative and the avoided implementation cost benefits associated with the keep dam no action alternative. These concepts are also included in the hypothetical dam removal BCA example presented in section 3.3.

3.1.1 Land and Facilities Acquisition: Typical Dam Removal Overall Effect: Not Applicable

Benefit-Cost Analysis Issues:

In a dam commissioning/construction analysis, the cost of purchasing the land and any associated structures would be included as a direct implementation cost in the BCA. With federal dam decommissioning/removal projects, the government already owns the land and facilities, therefore no such costs would be incurred.

If the federal government does not own a dam, but it is deemed in the public interest to remove it, the federal government may choose to purchase the dam, associated structures, and perhaps even the land. This was the case with the Elwha and Glines Canyon dam removal study (GAO,1991). From a societal perspective, the costs of constructing the dam have already been incurred by the private owner. As a result, they are sunk costs which would not be included in the economic analysis. The costs of acquiring the land, as in the dam commissioning analysis, would be included in the dam removal BCA as an implementation cost.

FERC is the federal agency responsible for overseeing how privately owned dams are operated and maintained. In its 1994 policy statement, FERC claims that it has authority to order removal of a dam at the end of a license term or impose environmental and endangered species improvement measures on privately owned dams, all at the owner's expense (FERC, 1994). It is FERC's policy that in certain circumstances, license conditions could be imposed to ensure necessary funds will be available for dam decommissioning when required. While FERC's position has yet to be officially tested in court, an article in the Washington Law Review agrees with FERC's position (Bryant, 1999). Assuming FERC's position is ultimately upheld in court, the federal government's purchase of privately owned dams to allow for dam removal may become an infrequent occurrence.

Recently, FERC exercised its authority when it denied a dam owner's application for a license to operate Edwards Dam on the Kennebec River in Maine. FERC ordered the dam removed at the owner's expense. An out of court settlement was developed to pay the costs of removal where upstream dam owners and a downstream shipbuilder shared the costs in exchange for relief from certain other obligations. The dam was removed in fall of 1999. The property was transferred to the City of Augusta for potential redevelopment. Out of court settlements between interested parties are increasingly being used to address dam removal costs or correct environmental problems which might otherwise lead to dam removal (American Rivers et al., 1999).

Dam commissioning vs decommissioning analyses: Land and dwelling purchases may be required to construct a dam. If applicable, such costs should be included in the dam commissioning BCA. In decommissioning analyses of a federal dam, land and facilities acquisition would generally not be necessary.

3.1.2 Dam Removal: Typical Dam Removal Overall Effect: Varies (Direct Implementation Cost & Avoided Cost Categories)

This element involves costs associated with actually dismantling or demolishing the dam and associated structures (e.g., intake structures, canals, tunnels, power facilities including transmission lines), including any costs of removing rubble from the site. To the extent that any of the structures or equipment could be salvaged and sold, costs should be adjusted downward accordingly. Another cost associated with this task involves controlling the river during dam removal through use of tunnels and canals to facilitate demolition, ensure safety, and maintain water quality by controlling sediment releases. Finally, to mitigate some of the lost benefits associated with removal of the dam, certain facilities may be constructed to allow for water access or flood control (e.g., pumps and levees).

In addition to these dam removal costs, the incremental analysis would also need to consider any avoided costs associated with the no action/baseline alternative. In a situation where structural and public safety issues are driving the dam removal proposal, the no action/baseline alternative would likely involve dam rehabilitation or even re-construction. According to a study of small dam removals in Wisconsin (Born et al., 1998), the costs of dam repair averaged three times the cost of dam removal. Such costs would represent an avoided cost benefit of dam removal.

Benefit-Cost Analysis Issues:

As noted above, in the future, the costs of removal for privately owned dams may be assigned to the dam owner, even when the decision to remove comes from an outside governmental source (e.g., FERC). Unfortunately, locating the dam owner may not always be easy since sometimes the dams have been abandoned. In such cases, dam removal costs would likely fall to a governmental body. Obviously, for dams owned by the federal government, the cost of removal would be incurred by the federal government.

Dam commissioning vs decommissioning analyses: Dam removal costs would be included in dam decommissioning analyses with the analogous costs of dam construction included in the commissioning analyses. Given the no action/baseline alternative in a dam commissioning analysis has no direct implementation costs, there would be no avoided cost benefits as with the dam decommissioning analysis.

3.1.3 Sediment Removal: Typical Dam Removal Overall Effect: Negative (Direct Implementation Cost Category)

Sediment removal represents the costs associated with dealing with the sediment build-up behind the dam. Assuming sediment is simply allowed to accumulate behind the dam as opposed to being periodically dredged, prior to dam removal, sediment is often dredged and removed, but other less costly options may exist including attempting to stabilize the sediment with concrete and plantings or gradually allowing it to dissipate downstream. Any attempt to release the sediment into the river must be accompanied by a stringent water quality plan with extensive monitoring. Gradual release of sediment can limit uses of the inundated area until after the sediment has been dissipated. Sediment, assuming it is present in sufficient quantities, needs to be removed or adequately controlled due to the potential impact on water quality and downstream fisheries. Another issue which needs to be studied is the make up of the sediments. In some cases, toxic contaminants are found in the sediment requiring special disposal methods

(Shuman, 1995). Addressing sediment is one of the major differences between a dam decommissioning analysis and a dam commissioning analysis.

Benefit-Cost Analysis Issues: Same comments as under dam removal.

Dam commissioning vs decommissioning analyses: Substantial one-time costs of removing or managing a large load of sediment are typically associated with dam decommissioning analyses, but not dam commissioning analyses. As noted below, any periodic removal of sediment included in a dam's maintenance program would be part of the dam commissioning analysis.

3.1.4 Site Stabilization and Restoration: Typical Dam Removal Overall Effect: Positive (Direct Implementation Cost & Avoided Cost Categories)

If the dam is breached as opposed to removed, the remaining structures may need to be stabilized to ensure safety. With either a removal or a breach, the site will need to be reshaped and revegetated to restore it to a more natural condition. Wetland maintenance or replacement may also be necessary.

In addition to these dam removal costs, the incremental analysis would also need to consider any avoided costs associated with the no action/baseline alternative. In cases where environmental factors, such as fish population declines, are driving the dam removal proposal, the no action/baseline alternative would likely involve a long-term habitat improvement plan. Such annual costs would need to be converted into a present value and would represent an avoided cost benefit of dam removal.

Benefit-Cost Analysis Issues: Same comments as under dam removal.

Dam commissioning vs decommissioning analyses: The costs of site stabilization and restoration would be only associated with dam decommissioning. However, with dam commissioning, there may be certain somewhat analogous site preparation costs which would need to be included. Given the no action/baseline alternative in a dam commissioning analysis has no direct implementation costs, there would be no avoided cost benefits as with the dam decommissioning analysis.

3.1.5 Operation and Maintenance (O&M): Typical Dam Removal Overall Effect: Negative (Direct Implementation Cost & Avoided Cost Categories)

If a dam is breached as opposed to removed, to avoid safety problems, certain long-term O&M costs may arise to maintain the remaining structures initially stabilized during the breaching process. Fencing off and installation of alarm systems for dangerous areas would be the first option to secure the site. On-going monitoring and periodic inspection efforts could also be implemented to maintain structural safety. Should water supply (e.g., pumps) or flood control structures (e.g., levees) be installed after dam removal or breach, these structures would require periodic on-going maintenance as well.

Regardless of whether the dam is breached or totally removed, land use changes may require management of the site. A popular program associated with many recent studies is the use of what is referred to as adaptive management. This approach involves ongoing monitoring of the river. As information is collected as to the overall health of the river and the fish and wildlife populations, adjustments are often necessary. Normally, the costs of adaptive management can be quite substantial, but with dam removal, the idea is to let nature take its course. As conditions improve, costs of adaptive management should decrease.

In addition to these dam removal costs, the incremental analysis would also need to consider any avoided costs associated with the no action/baseline alternative. Substantial costs are typically incurred on an annual basis to operate and maintain a dam. Maintenance and repair costs in particular tend to increase as the dam approaches the end of its useful life. Managing sediment accumulation is another potentially costly issue. Oftentimes, sediment is simply allowed to build up behind a dam. At some point, sediment fills up the reservoir, severely restricting its use. Instead of simply allowing sediment to accumulate unchecked, periodic dredging of sediment can extend the useful life of a project. With dam removal, many if not all of these annual or periodic maintenance costs would be eliminated creating an avoided cost benefit.

Benefit-Cost Analysis Issues: Same comments as under dam removal. Virtually all of the costs discussed in this section would be incurred annually and therefore would have to be converted/discounted into a present value for use in the BCA.

Dam commissioning vs decommissioning analyses: In both commissioning and decommissioning analyses, O&M costs would need to be considered. For decommissioning analyses, assuming the dam was to be completely removed, O&M costs may drop to zero, implying an avoided cost benefit compared to the no action/baseline alternative. No such avoided cost benefit would accrue under the dam commissioning scenario.

3.1.6 Water Rights: Typical Dam Removal Overall Effect: Not Applicable

In the western U. S., water is allocated among competing uses through application of a legally binding system of water rights. Water rights are based on longevity of use, where the oldest rights are honored first (“first in time, first in right”). The oldest of water rights are referred to as senior rights, with newer rights referred to as junior. In recent years, water rights holders have begun to sell their water rights to the highest bidder thereby creating a market in water rights.

Benefit-Cost Analysis Issues:

Legal issues may come into play as part of a dam removal process for federally owned projects. Water rights and long-term delivery contracts held by farmers, municipalities, etc. may influence the range of options to be considered. Costs of purchasing water rights or costs of maintaining access to legally assigned water supplies via in-river pumping devices may be incurred. Bottomline, the federal government would need to free itself from legal claims to the water prior to dam removal. Given water rights issues are so complex and case sensitive, a thorough evaluation of the impact upon them would be necessary prior to beginning the economic analysis.

It should be noted that markets for water are still in their infancy. While water rights and delivery contracts have been in place for years, procedures for redistributing water on a permanent or temporary basis are still being worked out. In many cases, there may be legal restrictions against using a given water right for other purposes. Water banks, institutional mechanisms for storing and loaning unused water, are starting up across the western states. Despite efforts to make water transactions easier, the ability to freely buy and sell water in an open market across competing water uses is still often constrained.

It may be necessary to purchase water rights to remove legal claims to the water, but from an economic analysis perspective, such costs would probably not be relevant to the BCA. The cost of the water right should compensate the owner for the loss of the water and should therefore be based at least to some degree on the present value of the lost long term benefit stream. Assuming the BCA would measure the potential long term loss in benefits associated with the use of the water, the cost of the water rights and the lost benefits would double count the impact.

Dam commissioning vs decommissioning analyses: Water rights purchases may be relevant for commissioning analyses, assuming water rights would need to be purchased along with private land and structures. However, water right purchases would likely double count estimated benefit losses associated with removing the dam and therefore would not be included in the analysis.

3.2 **OTHER DIRECT COSTS and BENEFITS**:

The following sections describe a wide range of negative other direct cost (lost benefit) or positive benefit impact categories. Consistent with Table 1 and the hypothetical example found in section 3.3, each category of impact is assigned to either an overall negative, other direct cost effect or an overall positive, beneficial effect based on the typically experienced result within a dam removal benefit-cost analysis. The other direct cost or benefit estimates can be measured using the various market or nonmarket based approaches presented in each section. Table 2 summarizes the typically employed BCA measurement approaches for each impact category.

Table 2: Typically Applied Benefit-Cost Analysis Measurement Approaches

Impact Category	**Consumer Surplus**	**Producer Surplus (profit)**	**Replacement Cost (market price)**	**Other**

I. *Market Based Approaches*:				
Fisheries: 1. Commercial Fishing: 2. Tribal Fishing: - Commercial Harvest - Subsistence Harvest - Recreational Harvest	U (net WTP)	U U	U	
Agriculture:		U		
Municipal and Industrial:	U (net WTP)		U	U (efficiency & water access costs)
Hydropower:			U	U (efficiency & air quality treatment costs)
Navigation:			U	
Flood Control:				U (costs of: flood prevention structures, structural strengthening, property damages)
Land Use:			U	
II. *Nonmarket Based Approaches*:				
Recreation:	U (net WTP)	U		
Nonuse Values:	U (total WTP)			

In virtually all categories, except for the selling off of inundated lands, the other direct costs or benefits would most likely be incurred on an annual basis. As a result, the alternative specific estimates developed for each year of the planning period would need to be discounted to the start of the planning period to calculate present values.

3.2.1 Market Based Other Direct Costs or Benefits:

The other direct cost and benefit categories described in this section reflect goods or services which are exchanged within a market setting. As a result, the valuation estimates for each category are derived using readily available market based information on quantity demanded, prices, variable and fixed costs, etc.

3.2.1.1 Fisheries: Typical Dam Removal Overall BCA Effect: Positive (Benefit & Other Direct Cost Categories)

Since the passage of NEPA, analytical consideration of the environmental demand for water, including fisheries purposes, has risen to the same level as consumptive uses of water. With the decline in fish populations across the western states, major efforts have been devoted to freeing up water for instream flows to aid fisheries recovery. Dam removal may affect a wide range of environmental conditions, many of which may not be easily quantifiable or convertible into dollar values. To the extent that environmental impacts cannot be measured, they should be qualitatively discussed within the BCA. While no measure can be all inclusive, studying the effects on fish populations, which are typically influenced by a number of environmental factors, often reflects a useful proxy for environmental change.

Generally, dam removal is expected to have a positive impact on fish populations and harvest. Opponents of dam removal claim that the biological science is at best uncertain, particularly the science associated with ocean migratory species, such as salmon. They claim that other non-dam factors including harvest, changing ocean environments, and predation are taking significant tolls on fish populations. They note that fish populations in rivers without dams are also in decline (Wade, 1999). Despite the claims of opponents, the majority of the biological and environmental community believe that increased fish populations would result from returning a river to a more natural state.

While the overall fisheries effect of removing a dam is often expected to be positive, to estimate the incremental gain it would be necessary to look at both the dam removal and keep dam alternatives. Estimated fish populations for the dam removal Action Alternative would need to be compared to those of the keep dam No Action/baseline condition to evaluate the net effect. Unless the No Action/baseline alternative completely eliminated all fisheries, both alternatives would need to be considered to evaluate the net effect. This logic of needing to evaluate with and without project conditions holds for the analysis of all project outputs. In Table 1, the potential fisheries values for the with project dam removal Action alternative are shown as a positive effect under the "benefit" column. To estimate the net effect, the existing fisheries values under the without project keep dam No Action/baseline alternative are shown as a negative effect under the "other direct cost" (or lost benefit) column.

It is possible that the types of fish species could change as a result of dam removal. This is because construction of dams may result in creation of habitat for non-native fish species. For example, dams sometimes allow for the stocking of warm water fisheries in the reservoir and cold water fisheries immediately downstream of the dam. With dam removal, either or both of the non-native fisheries may be eliminated as habitat conditions return to a more natural situation. Since fish species may vary between the action and no action/baseline alternatives, valuing the aggregated use (and nonuse) values associated with the fish populations for each alternative is a good way to evaluate the net effect of the change in fish populations.

Fishing can be separated into three general areas: recreational, commercial, and tribal. Since the recreational fishing component is discussed under the recreation section, only the commercial and tribal aspects are discussed here.

3.2.1.1.1 **Ocean Commercial Fishing**:

Commercial fishing for most species takes place in the ocean or at the mouth of rivers. Dam removal influences commercial fishing primarily through the increased population and harvest of migratory fish such as salmon and steelhead.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

‘ Change in Profitability at the Harvest Level

Change in commercial fishing profitability at the harvest level is basically measured by the additional pounds harvested times market price minus variable costs. Excess harvest capacity is often a characteristic of the commercial fishing industry and is therefore frequently assumed in commercial fishing analyses. Excess capacity implies that labor (fishing crews) and/or capital (boats and gear) are not being fully utilized. With harvest increases, as would be expected with a dam removal study, the excess capacity assumption implies the additional fish could be harvested without reducing harvest elsewhere. Taken to the extreme, assuming severe excess capacity with regard to labor and capital (e.g., crews could catch more per hour without extending fishing time), the additional harvest could be obtained with little to no variable costs, implying the additional harvest would be valued based upon market price alone.

Without getting into a prolonged discussion of the economic theory of vertically integrated markets or partial versus general equilibrium analyses, suffice it to say that in most cases of dam removal, the change in commercial fishing value is measured solely at the harvest level. The assumption is often made that the change in commercial fishing harvest as a result of removing the dam would not be significant enough to affect market prices. Stated differently, even if it were possible to combine them into a group targeting fish populations from a given river system, commercial fishermen are normally considered price takers, which implies they have little effect upon either supply or price within the overall market. As a result, consideration of changes in profitability in higher level markets (e.g., processors, wholesalers, or retailers) or other related economic sectors (e.g., restaurants) would not be necessary since the majority of benefits would accrue at the harvest level. For more information on this topic, see Just and Hueth (1979) or Just, Hueth, and Schmitz (1982).

From a theoretical perspective, the analysis should also include estimates of both producer surplus (profit) and consumer surplus (consumer WTP in excess of cost). Under the price taker assumption of insignificant impact on supply and price, changes in consumer surplus should not be noticeable. For all marketed goods and services presented in this paper, these general assumptions hold such that the focus is typically on a single measure (producer or consumer surplus) within a single market.

- General Methodology and Estimation Techniques:

The ocean commercial fishing analysis starts with biologists developing estimates of species specific fish populations. Such an analysis can be very involved taking into account potential changes in water quality (including temperature), quality and range of habitat/migration, instream flows, sediment movement, etc. Consideration is normally given to the entire watershed. For example, the effects of a removed dam may be substantially more pronounced within a single dam watershed compared to a multiple dam watershed. Removing one of several dams within a river system may not contribute to significant changes in populations of migratory fish species if downstream dams still block access to or from the ocean. These population estimates are often very difficult to develop. In many cases, biologists are unable to quantify the expected changes in fish populations. Without estimates of changing fish populations, there is little that can be done from an economics perspective.

If the biologists have enough data to estimate fish populations with and without the dam, the economic analysis proceeds with estimation of species specific fish harvest for the commercial, tribal, and recreational sectors. When evaluating threatened and endangered species, harvest may be precluded or severely restricted until the point of population recovery. Typically, these harvest estimates are based on catch to population ratios. Changes in commercial harvest are converted into changes in commercial fishing profitability based on market prices and variable harvest costs. If the change in harvest reflects a significant percentage of market supply, market prices may need to be adjusted and additional fixed cost investments (e.g., additional boats) may need to be considered. In addition, implications on higher level markets and other sectors may need to be considered. As noted above, the changes in harvest are typically not significant enough to warrant major price adjustment and analysis outside the harvest sector.

Substitution: Substitution or displacement effects may affect virtually all the analyses. From a fishing perspective, substitution effects can be many and varied. Both harvest level and consumer level substitution can occur.

1) Harvest Level Substitution: Commercial fishermen can substitute between different geographic areas or across fish species. However, as noted above, if sufficient excess capacity exists, additional harvest due to dam removal may be possible without affecting current harvest levels. If so, this would suggest that harvest substitution would not be necessary.

a) Geographic Substitution: Geographic substitution involves the movement of commercial fishermen from one area to another in search of a given fish species. Note that some vessels are geared toward a particular species of fish and it may be easier for them to move in search of that species as opposed to re-gear for other species. The huge vessels of the corporate commercial fishing fleets can easily move to different locations within U.S. or international waters as species populations change. Smaller non-corporate single boat businesses are also often forced to move around to different locations within U. S. waters in search of fish. To estimate the increase in commercial fishing profits attributable to a dam removal, the gain in profits due to the increased fish population from the improved river system may need to be tempered by the loss in profits associated with harvesting that species elsewhere. Given long-term harvest restrictions, excess harvest capacity often exists, whereby the additional harvest could be obtained without reducing time spent harvesting elsewhere, implying geographic substitution may be irrelevant. When present, estimating the substitution effect can be difficult, but it may be possible, after discussions with commercial fishermen, to generalize to some extent based on the type of vessels targeting the species. As with geographic substitution, evaluations of species substitution would require discussions with commercial fishermen.

b) Species Substitution: Species substitution occurs when commercial fishermen switch to other fish species as conditions change. With dam removal, the additional profit obtained from harvesting fish from the improved river system may need to be reduced by the profits lost from targeting other species, unless excess capacity exists. Obviously, fishermen would only switch species if it was profitable to do so. Given the range of potential species substitutions described below, this issue may be even more complex than geographic substitution.

1) Clearly Discernible Species Substitution: In many cases, corporate fleets or non-corporate boats may be able to direct their efforts to a range of fish species. As one species goes into decline, they switch to another species. So as dam removal increases fish populations to the point where they become commercially viable, it is possible the effort devoted to commercial harvest of that species would replace effort devoted to other fish species.

2) Similar Species Substitution: Biologists make a distinction between wild fish and hatchery fish. Wild fish are naturally occurring fish, native to the river in question. Wild fish can be used for commercial, tribal ceremonial/subsistence, or recreational harvest, or to maintain the natural ecology of the river system. Hatchery fish are raised to a certain age in pens within a given river system. Upon reaching the desired age, hatchery fish are released into the river, and live out their remaining lives within the "natural" ecosystem. Biologists suggest that hatchery fish are genetically distinct from and inferior to wild fish since they tend to be somewhat smaller and more susceptible to disease. Additionally, hatchery fish adversely affect wild fish by competing for food and diluting their genetic purity. Hatchery fish can be used for commercial or recreational harvest, but probably not for tribal ceremonial or ecological purposes. As a result, even from an economic perspective, many would claim wild fish and hatchery fish to be separate products.[4] Unfortunately, in most cases, it may be virtually impossible for an unskilled eye to distinguish between commercially harvested wild fish versus hatchery fish.

---

[4] Values per fish vary considerably depending on how the fish is "used". Recreational values per fish are typically much greater than commercial values. Also, nonuse value per fish often greatly exceed recreational values, as when T&E species are involved. The problem arises in that it is virtually impossible to distinguish between wild fish and hatchery fish during harvest. As a result, there are potential differences in value between a farmed fish (commercial purposes only), a hatchery fish (commercial and recreational purposes), and a wild fish (commercial, tribal, recreational, nonuse purposes). Economic analysis needs to treat these different categories of fish as separate and distinct products (Morlan, 1999).

> Even if one agrees with the separate product argument, wild and hatchery fish are still substitutes. They may not be perfect substitutes, given their values may not be the same (e.g., wild fish may command a higher price), but they are substitutes. To the extent that the commercial harvest of wild fish may increase with dam removal, the analysis may also need to consider the reduction in harvest value of hatchery fish (logically, as wild fish populations recover, the use of the hatcheries would decline).

2) Consumer Level Substitution: From the consumer perspective, the range of options could conceptually include wild fish harvested domestically, hatchery fish harvested domestically, farmed fish produced domestically, and imported fish.

Farmed fish are raised in pens typically in coastal estuaries and bays. These fish are destined exclusively for markets, so they have no harvest implications. But farmed fish obviously contribute to the worldwide consumption. As with the above discussion of wild versus hatchery fish, it is possible that wild fish may be product differentiated from farmed fish such that wild fish may command a higher price. However, farmed fish do represent a substitute for wild fish whereby an increase in wild fish harvest may adversely affect the production and profitability of the farmed fish industry.

The consumer also has the option of purchasing imported fish. Increased consumption of domestically harvested fish as a result of dam removal, could adversely affect international fishing industries exporting to the U.S. Since benefit-cost analyses use a national perspective, impacts upon the profitability of international fishing industries would not be considered.

Dismissing the exceeding unlikely event that the change in commercial harvest of wild fish due to dam removal would represent a significant portion of the supply of fish available in the market, the additional quantity of dam removal induced wild fish would probably have very little influence on consumer selection decisions and retail market supply substitution.

Dam commissioning vs decommissioning analyses: After taking into account the range of potential substitutions, the anticipated net effect on commercial fishing would typically be positive for decommissioning studies and negative for commissioning studies. In both analyses, evaluation of Action Alternative (benefits) and No Action Alternative (other direct costs) would be necessary to estimate the net effect.

Analytical approaches should be similar for both study types except for the potential influence of excess capacity. Under a dam decommissioning scenario, assuming sufficient excess capacity exists, gains in harvest could be obtained without reducing harvest elsewhere or for another species. This implies that with sufficient excess capacity, one would not need to consider harvest substitution. Conversely, under a dam commissioning scenario, the existence of excess capacity may imply a substitution effect. With excess capacity, commercial fleets aren't being fully utilized. Further potential reductions in harvest due to dam construction may imply the commercial fishermen would be more prone to move elsewhere or change gears to target other species to a greater degree than they currently do. Hence, substitution issues may need to be considered under excess capacity within a dam commissioning analysis. Under a scenario of no excess capacity, both decommissioning and commissioning analyses would be similar in that they both would need to address substitution.

3.2.1.1.2 **Tribal Fishing**:

Tribal fishing can take place either in the ocean or in the river depending on the location of the reservations. Given tribes are often allocated a sizeable percentage of a river's allowable harvest, it is important to address this component. Typically, tribal harvest is either commercially sold or kept for subsistence or ceremonial purposes. In some cases, the tribes have created a permit based recreational fishery where non-tribal anglers can harvest a portion of the tribal allocation for a fee. Generally, dam removal is expected to have a positive impact on fisheries, including all aspects of tribal harvest.

Benefit-Cost Analysis Issues:

1) Ceremonial harvest: Many tribes conduct spiritual ceremonies using traditionally harvested fish.

- Practical Measurement Approaches:

‘ None: Of the various components of tribal harvest, estimating benefits associated with ceremonial harvest is by far the most difficult from an economics perspective. Typically, the assumption is made that economists simply cannot place a dollar value on ceremonial harvest since these activities are of a spiritual nature.

- General Methodology and Estimation Techniques: Not applicable

2) Commercial harvest:

- Practical Measurement Approaches:

‘ Change in Commercial Fishing Profitability.

- General Methodology and Estimation Techniques:

Commercial values can be estimated using the approaches described previously in the ocean commercial fishing section. It should be noted that harvest practices employed by tribal fishermen may vary considerably from those of non-tribal fishermen, particularly compared to the large scale non-tribal commercial harvesters which often dominate the market. As a result, the variable costs of harvest may be quite different for tribal fishermen. In addition, it is possible that the actual traditional harvest practices themselves may hold certain spiritual values. For purposes of the benefit-cost analysis, consistent with the ceremonial harvest discussion, such values are generally considered incalculable.

Substitution: Assuming tribal commercial fishermen harvest primarily on the reservation, substitution options would be substantially diminished compared to non-tribal fishermen. The geographic area and range of substitute species would likely be extremely limited. While it is possible the consumer level substitution issues may still apply, it is unlikely that substitution effects would play an important role in the tribal commercial fishing analysis.

Dam commissioning vs decommissioning analyses: See non-tribal commercial fishing discussion.

3) Subsistence harvest: Many tribes have rights to fish which are used as a primary food source for low income tribal members.

- Practical Measurement Approaches:

‘ Market Price or Willingness-to-pay

- General Methodology and Estimation Techniques:

Subsistence harvest would be estimated from the change in fish populations as estimated by the biologists. Using the overall estimate of tribal harvest, the various components of tribal harvest would likely be calculated based on population based need and/or historical percentages. Once the additional subsistence harvest is estimated, pure subsistence values could presumably be estimated based on the cost of purchasing that variety of fish at a grocery store.

The concept of a pure subsistence value, based exclusively on the subsistence value of fish consumed, probably does not apply to tribal subsistence harvest. It is more likely tribal subsistence and ceremonial values are intertwined. If so, there may be some potential to get at these combined values via contingent valuation WTP surveys. However, as noted above, the ceremonial/spiritual nature of the values may be immeasurable.

Dam commissioning vs decommissioning analyses: The anticipated net effect on subsistence fishing would likely be positive for decommissioning studies and negative for commissioning studies. The analytical approach would be the same for both studies and would include the need to measure subsistence values with and without the project.

4) Recreational harvest:

- Practical Measurement Approaches:

‘ Change in Recreator Values are measured in terms of Net Willingness-to-Pay or Consumer Surplus.

‘ Change in Profitability of Tribal Commercial Operators

- General Methodology and Estimation Techniques:

Recreation values can be estimated using the approaches described in the recreation section.

Dam commissioning vs decommissioning analyses: See discussion within the recreation section.

3.2.1.2 Agriculture: Typical Dam Removal Overall BCA Effect: Negative (Other Direct Cost & Benefit Categories)

While nationwide and worldwide demand for food continues to rise as populations increase, water supplies used for agriculture have actually decreased in the U. S. as farmers and water distribution systems have become more efficient. Increasing water demands in recent years for M&I and environmental uses in particular have also started pulling water away from agriculture.

Agricultural analyses are often required in dam removal studies given one of the primary objectives of a dam may be to provide water for irrigation. Despite the potential for continued water access through use of in-river pumping, lost reservoir storage due to dam removal would likely result in a reduction in agricultural water supply and/or a change in the timing of available agricultural water. In either case, farmers would either have to replace lost water supplies from other available sources (e.g., groundwater, purchased water), or simply do without. If reasonably priced comparable quality long-term replacement water supplies were available, agricultural production might not be significantly affected. However, if replacement water supplies could not be obtained or proved to costly, farmers would have to adjust by switching to more efficient irrigation methods, switching to less water consuming crops, or decreasing irrigated acreage. The result would presumably be a reduction in output and revenue. In either case, it is likely that agricultural profitability would decline. To adequately address the potential change in agricultural profitability, the analysis would obviously need to study conditions under both the Action and No Action/baseline alternatives. In Table 1, this concept is shown by identifying impacts under both the other direct costs and benefit categories.

In most cases throughout the western U. S., individual farmers or agricultural water districts hold the rights to the water stored in reservoirs. Before pursuing removal of a dam, from a practical perspective water rights holders would have to be accommodated through the purchasing of water rights or the provision of alternative sources of water. As noted in the water rights section (3.1.6), water rights purchases would not be included in the economic analysis since they would double count potential losses in agriculture.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

‘ Change in Agricultural Profitability or Net Farm Income

Farmers are assumed to be price takers meaning that they have very little control over market prices and must therefore accept the offered price. As a result, any increase in the cost of water would be absorbed by the farmer and could not be passed along to processors, wholesalers, retailers, or consumers.

- General Methodology and Estimation Techniques:

Changes in agricultural profitability are affected by the availability and increased cost of irrigation water. As noted above, if adequate water supply alternatives exist, agricultural output may not suffer, in which case changes in profitability would be based on the increased costs of pumped and/or purchased replacement water in excess of current water supply costs. Conceptually, the cost of replacement water would be expected to increase after dam removal as replacement water demands increase. As a practical matter, it would be difficult to predict how prices might change, therefore current costs would likely be used as an approximation. To some extent, increased irrigation water costs, as an input to agricultural production, may reduce agricultural output and revenue even if sufficient replacement water supplies exist. As a result, the effect on profitability may be more complex than simply measuring the increased cost of irrigation water. When adequate replacement water supplies do not exist, lost agricultural output would likely result. In this case, the change in profitability would be driven by both the lost production/revenue and the increased water costs. The lost production/revenue aspect would need to take into account the range of potential on farm adjustments including irrigation efficiency, crop substitution, land fallowing/retirement, etc. Use of input price elasticities or mathematical programming methods may be required to adequately estimate long-term changes in profitability.

When evaluating changes in agricultural profitability, consideration should also be given to the influence of federal subsidies. It is possible that a portion of agricultural profitability for a given product may be comprised of federal subsidies. Some farmers potentially benefit from federal subsidies related to both the cost of irrigation water and the price received for surplus crops. To be consistent with other unsubsidized benefit measures, when possible, estimates of the changes in agricultural profitability should be based on unsubsidized water costs and commodity prices. With dam removal, if replacement water is obtained through some sort of market mechanism (e.g., water bank, transactions between individuals), the price of that water should be based on supply and demand interactions and therefore would not reflect a subsidized cost. If replacement water was obtained from another federal project with excess water supply, the cost of that water would likely be subsidized. Without dam removal, the current cost of water would also be subsidized given it is based on project costs allocated to agriculture as obtained from the most recent cost allocation. Instead of using the subsidized costs of water, when available, it may make sense to use unsubsidized costs as obtained from water markets. Finally, unsubsidized normalized prices are available by commodity and state from the U. S. Economics Research Service (ERS).

Substitution: Assuming agriculture experiences a loss in water supply with dam removal, the first step in the substitution analysis would involve deciding how the mix of crops and irrigated acreage might adjust. This on-farm substitution analysis would consider potential changes in crop mix, irrigation approaches, fallowing/land retirement decisions, etc. These substitution options could be included within linear programming optimization models developed to reflect the agricultural sector. When models are unavailable, these substitution effects must be individually addressed by the analyst.

The handling of geographic substitution within a P&G based agricultural analysis varies depending on the crop category. Two crop categories exist, basic crops and non-basic or specialty crops. For the ten "basic" crops (i.e., rice, cotton, corn, soybeans, wheat, milo, barley, oats, hay, and pasture), the P&G state that no water resources project would affect price or cause geographic transfers of production given the production of basic crops are limited primarily by the availability of suitable land. This implies that there exists excess demand for these crops and that the country is producing as much of these crops as possible. Since we are at maximum production, a loss in production due to dam removal could not be offset by production gains elsewhere. So, there is no potential for geographic substitution within these basic crops. For non-basic or specialty crops, no excess demand or land suitability limitations are assumed, implying an analysis of possible geographic substitution should be conducted. While geographic substitution is often likely with non-basic crops, in certain cases such substitution may not be possible. Certain crops, as with citrus, may require special climatic conditions not readily available throughout the country.

Another form of substitution which is implicitly addressed within the agricultural analysis relates to the substitution of uses of the replacement water. Unless excess water supply exists such that the water is not being used (typically an unlikely event given that most western rivers are overappropriated), water obtained to replace lost irrigation water as a result of dam removal would imply a reduction in some other use of the water. While it would be exceedingly difficult to determine from what uses the replacement water came from, theoretically the price of the replacement water should reflect the opportunity cost of its alternative uses.

Dam commissioning vs decommissioning analyses: The anticipated overall effect on agriculture would likely be negative for decommissioning studies and positive for commissioning studies after taking into account both the Action Alternative (benefits) and No Action Alternative (other direct costs). Similar analytical procedures would be used in each case.

3.2.1.3 Municipal & Industrial (M&I): Typical Dam Removal Overall BCA Effect: Negative (Other Direct Cost & Benefit Categories)

The demand for M&I water has increased in recent years to keep pace with expanding populations. This is particularly pronounced in the western U. S. where populations, especially urban populations, continue to rise sharply. M&I demands have increased to the point where, by offering higher prices, they have begun attracting water away from agriculture.

M&I water supplies can be adversely affected by dam removal, although typically not to the extent that agriculture is affected due to the lower volume of water involved. Although M&I supplies may be pulled directly from the river after dam removal, losses in reservoir water storage capacity would likely imply M&I water shortages in certain years. If M&I water districts hold rights to the water, including the stored reservoir water, from a practical perspective specific accommodations would need to be made such as purchasing the water rights or obtaining alternative sources of water. As noted in the water rights section (3.1.6), water rights purchases would not be included in the economic analysis since they would double count potential losses in M&I. Even if the cities or businesses have no legal claim to the potentially lost water supply, actions would still likely be required.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

  ‘ Societal Net Willingness-to-Pay (Consumer Surplus):

  Consumer surplus reflects societal value for goods and services in excess of what was expended to obtain them. Consumer surplus is typically measured by the aggregation of individual consumer willingness-to-pay in excess of price or cost.

- Increased Cost of Alternative Water Supply.

  Cost of replacement water should be based on market price as obtained from a competitive market. When obtained from another municipality, the price of replacement water is normally based on average costs. Increased costs reflect the additional costs incurred in excess of current costs.

- Efficiency Costs

  Cost of programs which increase efficiency in the use of water (e.g., water conservation programs).

- Water Access Costs:

  Construction and Annual Operating and Maintenance Costs of Pumps for continued water access (costs: purchase price, installation, electricity, maintenance, etc.)

- Increased Water Treatment Costs:

  Additional water treatment costs associated with new water supplies.

- General Methodology and Estimation Techniques:

Conceptually, assuming municipal water districts own the property rights to the water, the value of potential losses in municipal water supplies would be measured by the water users willingness-to-accept (WTA) compensation for the loss in water supply. Recent studies have begun to use contingent valuation survey techniques to measure willingness-to-pay (WTP) to avoid municipal water losses as a proxy for WTA. WTP is often used to drastically reduce the potential for infinite value responses characteristic of WTA studies. As a result, WTP could be considered a conservative estimate of WTA. Developing contingent valuation surveys to estimate WTP to prevent a loss in water supply may be difficult to implement in a dam removal context since respondents may object to the idea of paying to avoid dam removal. It may be necessary to frame the WTP questions simply in terms of preventing the water supply loss without bringing in the issue of dam removal. Such surveys could be used to measure WTP for both residential and municipal uses (e.g., public buildings, parks and recreation, fire protection).

Another option for measuring WTP involves the estimation of demand curves. Statistical procedures are used to estimate a relationship between the quantity of water demanded and a range of explanatory variables (quantity = f (price, household size, household income, climatic conditions, etc.)). The area under the demand curve provides an estimate of WTP. This approach is most applicable to measuring the value of losses in residential use.

Alternatively, losses in municipal benefits could be measured in terms of the increased cost of alternative water sources. Assuming sufficient replacement water could be found, it would be preferable to measure increased water costs, in excess of current costs, using competitive market prices. In some instances, water markets or water banking systems exist resulting in competitive prices. In a competitive market, where price equals marginal cost, market prices could be used to reflect society's WTP for a replacement water supply. Unfortunately, in most cases, competitive markets do not exist. Exchanges of water between municipalities are often based on average cost pricing which typically understates the marginal or incremental cost of obtaining additional water supplies. Average cost pricing is based on the average cost of all water supply sources and not the costs of obtaining additional marginal or incremental supplies. While not conceptually correct, the replacement cost of lost water supplies are often based on average cost pricing.

To calculate total future water demand, projected estimates of future populations would be applied to average per capita water demand. Average per capita demand could be influenced by the success of any proposed water conservation programs, the costs of which would have to be entered into the analysis. If the replacement water was of a lesser quality, an analysis of the change in treatment costs may also be necessary. If water supplies could be at least partially met from pulling water directly from a river, the costs of pumping and transporting the water would need to be included. Assuming household water prices would increase as utilities pass along the increased costs of all these elements of replacement water, consideration may need to be given to the price effect on demand should the increase in prices be significant.

A representative price elasticity of demand could be used to adjust quantity demanded to the increased price. Price elasticities of demand ($g_{w,p}$) represent the percentage change in water demand divided by the percentage change in price. When the percentage change in demand is less than the percentage change in price, the $g_{w,p}$ is less than 1 and is referred to as being inelastic, the opposite is referred to as being elastic. Price elasticities can vary geographically, by season, and by type of use (indoor use is often more inelastic than outdoor use).

An evaluation of a change in water supply to commercial and industrial businesses would follow a similar procedure as described under the agricultural analysis. As with the agricultural analysis, the assumption is often made that firms within a particular industry are price takers in the national and international markets, therefore costs cannot be passed on and the focus is on the manufacturing level. Ultimately, costs associated with purchasing replacement water and/or more efficiently using existing water supplies would manifest themselves in reductions in industrial profitability. The first step would involve determining which businesses would experience a shortage, and then determine the availability and cost of replacement water. Assuming a full supply of replacement water would be unavailable, impacts upon production and profitability would need to be made after taking into consideration possible water conserving production process efficiencies. Given the wide range of potentially affected businesses, this analysis could obviously get exceedingly involved.

Having said this, it should be noted that impacts to commercial and industrial profitability are often excluded from M&I analyses. Perhaps the primary reason for the exclusion is that water costs typically reflect only a very small fraction of total production costs. This is true even for industries that use sizable amounts of water (e.g., electric power, primary metals, chemicals, petroleum and coal products, pulp and paper). As a result, the replacement cost of water or the increased water conservation costs would have to be extensive before they would have much effect on industrial profitability.

For all measurement approaches, the additional WTP or cost component is based on some form of with and without project analysis. For example, if one used a contingent valuation survey to estimate WTP to avoid a loss in water supply, the first question which must be answered is the amount of water supply expected to be lost. Consideration of what level of M&I water supply would be available under each alternative would be required to measure the loss. While it may be possible to measure the probable incremental loss in economic value related to M&I directly, as opposed to measuring values for each alternative and subtracting, in either case, consideration must be given to both the Action and No Action/baseline alternatives. In Table 1, this concept is shown by identifying impacts under both the other direct costs and benefits categories.

Substitution: The only form of substitution which seems relevant for the municipal analysis relates to the substitution of uses of the replacement water. Unless excess water supply currently exists such that water is not being used, water obtained to replace lost municipal water as a result of dam removal would imply a reduction in some other use of the water. While it would be exceedingly difficult to determine from what uses the replacement water came from, theoretically if the price of the replacement water is based on competitive market prices, that price should reflect the opportunity cost of alternative uses. From the industrial perspective, the primary substitution effect to account for would likely be the possible nationwide geographic substitution stemming from possible losses in production. If the loss in production due to dam removal was insignificant as a percentage of overall market supply, it is probable that the degree of geographic substitution would be minor.

Dam commissioning vs decommissioning analyses: The anticipated overall effect on M&I would likely be negative for decommissioning studies and positive for commissioning studies. The analytical approach would be similar for both studies.

3.2.1.4 Hydropower: Typical Dam Removal BCA Effect: Negative (Other Direct Cost & Benefit Categories)

Hydropower is a popular electricity generation source relative to other options (e.g., coal, gas, nuclear) because it is generally inexpensive, requires less maintenance and shutdowns, uses a renewable resource in water, doesn't produce air pollution or radioactive waste, and is extremely flexible since it can be used to meet either continuous baseload or periodic peaking power needs.

Hydropower, while often not a primary project purpose of federal dams, still represents a substantial project benefit and revenue source. Dam removal and the associated loss of water storage generally eliminates the possibility of hydropower generation.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

  - Additional Cost of Replacement Power as measured by long-term market price or the least cost alternative.

    The additional cost of replacement power is equal to the cost of the replacement power minus the costs which would have been incurred to generate the lost hydropower.

  - Cost of Energy Efficiency Programs

  - Cost of Air Quality Treatment

- General Methodology and Estimation Techniques:

Lost power generation due to dam removal would need to be evaluated in terms of the overall long term capacity of the power system. Hydropower often reflects only a small portion of a region's electrical production given it is but one of several available generation sources.

> If the power system is expected to have long term excess capacity, such that the lost generation due to dam removal could be made up by existing alternative sources, then the lost generation could be valued in terms of the additional energy cost of generating replacement power in excess of the No Action Alternative costs of generating the hydropower. Ideally, the cost of replacement power would be measured by market price which would be based on variable production or marginal costs. With the gradual deregulation of the electricity industry, competitive market prices are developing based upon marginal costs of production as opposed to historically applied average costs. From an economic theory perspective, marginal costs are a better indicator of replacement cost than average costs.
>
> If the power system is not expected to have sufficient long term excess capacity, the value of the lost hydropower generation should be based on the additional long-term cost of producing replacement power in excess of the No Action Alternative costs of hydropower. The long-term replacement cost includes both energy and capacity components and represents the least cost alternative generation method. Capacity costs reflect the capital costs of building new plants or expanding existing ones (Task Committee, 1997).

When evaluating the capacity costs, how the electricity is used may be relevant. For example, hydropower plants are often used to produce peaking power. Since hydro plants can quickly increase or decrease the amount of power they generate, they are ideally suited to respond to rapid changes in demand. To replace a hydro plant, consideration should be given to a plant with similar capability (e.g., gas or oil fired plant). Note that the capacity of the plant used to replace the hydropower plant may have to be different due to varying spinning reserve requirements. Spinning reserves represent turbines kept in motion to instantaneously cater to changes in demand. Different spinning reserve requirements associated with different types of powerplants imply identical megawatt capacities cannot be directly substituted (e.g., 200 MW hydropower plant may require replacement by greater than a 200 MW gas fired plant).

An extension of the above approach is described in Huppert (1999). To measure losses in hydropower generation, he suggests using an adjusted replacement cost based on the least cost alternative generating method. Given the alternative generating method could increase the average price of electricity, Huppert suggests demand may need to be adjusted downward using price elasticities. The degree of impact on prices would depend on the level of excess capacity in the system, the amount of power needing replacement, and the comparative costs of the replacement options.

In many ways, the hydropower analysis is similar to the M&I analysis. As with the M&I analysis, electricity reflects a final good to the household and an input to industry. This implies that the hydropower analysis would need to consider both residential and industrial impacts.

The P&Gs suggest that gains in hydropower benefits to the general public could be measured in terms of societal WTP. Losses in hydropower benefits could conceptually be measured in terms of societal WTA. Unless an analysis allows for a contingent value survey of power users, WTP/WTA information will not be available. In lieu of WTA, the P&Gs suggest using market price when it is based on marginal costs, or the additional cost of the most likely alternative generating method when prices are based on average costs. To the extent that it would be reasonable to implement energy conservation programs to reduce household demand for electricity, it may be that all the lost generating capacity need not be fully replaced. Should energy efficiency become part of the mix, the cost of efficiency programs would need to be factored into the residential power analysis.

Hydropower is also used by industry. The industry analysis would be similar to the discussion described under the M&I and agricultural analyses. The assumption is often made that firms within a particular industry are price takers in the national and international markets, therefore costs cannot be passed on and the focus is on the manufacturing level. The first step would involve determining which businesses would be affected, and then determine the availability and cost of replacement power. If a full supply of replacement power would be unavailable at least in the short run, impacts upon industry production and profitability would need to be estimated after taking into consideration possible electricity conservation production options. Given the wide range of potentially affected businesses, this analysis could become exceedingly involved.

Given that hydropower produces electricity without polluting the air with carbon dioxide emissions or other greenhouse gases[5], use of polluting replacement generation sources as a result of dam removal would require consideration of potential air pollution effects. The additional pollution could be valued in economic terms based on the additional costs of air quality treatment or use of renewable energy sources (Marcus and Garrison, 2000).

To adequately address the potential change in power generation costs, the analysis would obviously need to study conditions under both the Action and No Action/baseline alternatives. In Table 1, this concept is shown by identifying impacts under both the other direct costs and benefits categories. While hydropower generation would most likely be completely eliminated with the removal of a dam, the potential for power generation from other sources necessitates a power analysis for the Action Alternative dam removal scenario (i.e., the lost hydropower generation may be offset by other generation sources).

Substitution: Substitution between electricity generation options, from hydropower to other forms of generation as a result of dam removal, reflects the primary emphasis of the hydropower analysis. Evaluation of the least cost replacement options, along with determination of available capacity, explicitly accounts for substitution. From the industrial perspective, the primary substitution effect would be the possible nationwide geographic substitution related to the lost production. If the loss in production due to dam removal was insignificant as a percentage of overall market supply, it is probable that the degree of geographic substitution would be minor.

Dam commissioning vs decommissioning analyses: The anticipated overall effect on power generation would likely be negative for decommissioning studies and positive for commissioning studies.

The analytical approach would be similar for both types of studies except perhaps when the power system is currently running at full capacity (i.e., excess capacity does not exist). With the power system running at full capacity, a reduction in hydropower generation due to dam decommissioning would imply other generation sources cannot produce any more power in the short run to make up for the lost generation. The lost hydropower benefits due to dam decommissioning would therefore be based on the Action Alternative energy and capacity costs of a new power plant minus the No Action Alternative cost of hydropower generation.

[5] This is not to suggest that dams and hydropower are environmental friendly options. The environmental problems attributable to dam construction and hydropower operations are well known. However, once the dam is in place, and much of the environmental damage has been done, hydropower generation can be relatively clean particularly if dam operations release water to replicate natural conditions (environmentally friendly water release patterns can obviously reduce the generation flexibility of the facilities). With regard to greenhouse gases, recent evidence suggests that reservoirs all emit greenhouse gases due to the rotting of vegetation. These emissions can be significant relative to those emitted by thermal plants (World Commission on Dams, 2000).

Conversely, in a dam commissioning analysis, full capacity within the power system would imply additional generation from the new dam's power plant would offset generation from other sources assuming demand was being met. The additional with project power generation from the new dam's plant would be valued based on the energy cost savings associated with the new plant as compared to the without project previously used generation sources. If demand is not being met and the power system is at full capacity, the additional generation from the new plant would not displace other power sources, and would be valued at both the energy and capacity costs of the new plant. Under excess capacity situations, demand would be fully met and both dam decommissioning and dam commissioning analyses would need to take into consideration substitution to and from other power generation sources to measure the change in power generation costs between the with and without project alternatives.

3.2.1.5 Navigation: Typical Dam Removal BCA Effect: Negative (Other Direct Cost & Benefit Categories)

Navigation on inland waterways, such as the Mississippi and Columbia Rivers, comprises an important component of the transportation industry. Barge traffic, which represents the vast majority of inland navigation, is typically used to transport nonperishable bulk commodities such as coal and grain. Barges are generally the cheapest form of transit for these types of commodities in part due to sizable federal subsidies. While the transportation industry also includes airline, truck, and pipeline modes, railroads are often the primary transit substitute for inland navigation.

Navigation is a primary project purpose on many Corps dams and some Reclamation dams. As a result, estimating impacts to the navigation industry is often important. Given many dams were constructed to store water to allow for inland navigation, dam removal typically reduces or eliminates navigation within certain stretches of a river system.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

‘ Increased Cost of Alternative Transportation as measured by market price.

Increased cost of alternative transportation is equal to the cost of the next best alternative transit method minus the transit costs which would have been incurred under navigation.

- General Methodology and Estimation Techniques:

Removal of a dam and the resultant loss in reservoir storage would likely imply adverse impacts to or complete elimination of navigation in the area. In theory, given that navigation is an input to production, navigation restrictions would manifest themselves in changes in manufacturer's profitability for those products which transport using navigation. Application of the price taker assumption, previously noted under agriculture, M&I, and hydropower, would result in an analytical focus on profitability at the manufacturing level. In practice, losses in navigation are typically measured in terms of the additional cost of the least expensive alternative transportation option compared to the costs of navigation. This is a simplification given the downward effect of increasing transportation prices on production is ignored using the unadjusted replacement cost concept. Realistically, trying to evaluate the price effect and the change in profitability for the range of products making use of navigation would be a daunting task. Depending on how significant transportation costs are compared to the other costs of production, the effect of a transportation price increase on level of production may be minimal.

When evaluating changes in navigation costs, consideration should also be given to the influence of federal subsidies. From a societal perspective, it is likely that a sizable portion of full navigation costs may reflect federal subsidies. If possible, the amount of subsidy to inland navigation and other transit modes, could be added into the dam decommissioning calculation when attempting to determine the additional costs of the next best transportation alternative. From a national perspective, society pays the full cost of inland navigation transit through a combination of federal taxes and retail prices of transported goods. Having said this, it should be noted that it would probably be extremely difficult to develop an estimate as to the level of federal subsidy.

Determination of the least expensive alternative mode of transportation is not as simple as reviewing the rates charged by the alternative modes of transit. Consideration would also need to be given to transit time and costs of temporary storage. Also, it is possible the alternative transit modes may have insufficient capacity to absorb the additional freight, implying additional investment may be necessary, possibly creating price changes (Morlan, 1999).

Another factor to consider would be the environmental consequences of switching modes of transportation. If it is assumed that truck transit is used at least in part in lieu of navigation, there may be an impact on air pollution (Moxon, 1999). Unfortunately, it may not be possible to treat the additional truck based pollution to prevent it from entering the environment. While navigation appears to provide an air quality benefit, the industry often creates water quality problems which would need to be factored into the analysis.

To adequately address the potential change in transportation costs, the analysis would obviously need to study conditions under both the Action and No Action/baseline alternatives. In Table 1, this concept is shown by identifying impacts under both the other direct costs and benefits categories. While navigation would most likely be completely eliminated with the removal of a dam, the potential for using other sources necessitates a transportation analysis for the with project dam removal alternative (i.e., the lost navigation may be offset by other transit sources).

Substitution: Substitution between transit modes, from navigation to other forms of transit as a result of dam removal, reflects the primary emphasis of the navigation analysis. Unless there are nationwide implications of a switch from navigation to some other form of transit, a navigation analysis, based on current costs, would explicitly address substitution in the determination of the increased cost of alternative forms of transit.

Dam commissioning vs decommissioning analyses: The anticipated overall effect on transportation would likely be negative for decommissioning studies and positive for commissioning studies. The analytical approach would be essentially the same for both studies.

3.2.1.6 Flood Control: Typical Dam Removal BCA Effect: Negative (Other Direct Cost & Benefit Categories)

Flood control is a basic function of most dams. Storing and harnessing flood waters for future use is a primary project purpose for virtually any system of dams. The main purpose of flood control is to reduce flood hazard in terms of both flood damages and loss of life.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

‘ Cost of Flood Prevention Structures

‘ Cost of Land Purchases

‘ Cost of Structural Strengthening

‘ Change in Expected Value of Flood Damages (e.g., property and infrastructure, income loss, emergency costs)

- General Methodology and Estimation Techniques:

Dam removal or breach would likely increase the risk and frequency of flooding. To offset the increased flood risk, downstream channel management measures may be necessary under the dam removal alternative (e.g., construction of dikes and levees). Alternatively, lands and buildings could be purchased to remove them from the enlarged uncontrolled flood plain. Also, roads and bridges may have to be strengthened, rebuilt, or moved to withstand flood flows. The above mentioned costs would hopefully reduce or eliminate certain potential flood damages.

Ultimately, the flood control analysis would evaluate the expected value of flood damages with and without the dam. Expected value is estimated by multiplying the potential flood damages by the associated flood probabilities. The difference in the present value of expected flood damages between the action and no action alternatives reflects the flood damage cost (if negative) or benefit (if positive) within the context of an incremental analysis. Another way to look at this is to measure flood control benefits based on the avoided flood damages associated with each alternative. If the dam removal and no action alternatives both included some sort of flood control procedure (i.e., levees and the dam respectively), differences could be estimated between flood damages which might occur without any flood control procedures and those which might occur with each alternative. Of course, these avoided damage flood control benefits could only be measured if we had an estimate of the flood damages without any flood control procedures.

While the probability a wide range of floods will increase with dam removal, one flood oriented advantage does result. The problem of trying to manage for the possibility of a catastrophic dam failure is eliminated. By removing or breaching the dam, storage water is evacuated, eliminating the potential problems associated with the sudden release of the impounded water. As dams age, the probability of dam failure increases. The issue of dam safety may be an overriding, non-economic factor driving the dam removal analysis. While some effort has been devoted by economists to valuing human life, the extremely controversial nature of the concept precludes serious application of the methodology. When dealing with potential loss of human life, the decision may ultimately be based on some sort of cost effectiveness analysis where the selection is based on the least cost solution which would ensure public safety.

Despite the negative connotation associated with flooding, one advantage of dam removal from the perspective of flooding is the potential creation of additional fish and wildlife habitat. Annual or periodic flooding may create wetland and other backwater habitat important for a wide range of plant and animal species. Habitat creation would likely be one of the more critical factors involved in attempts at estimating changes in fish and wildlife populations.

To adequately address the potential change in flooding, the analysis would obviously need to study conditions under both the Action and No Action/baseline alternatives. In Table 1, this concept is shown by identifying impacts under both the other direct costs and benefits categories. While dam based flood control would be completely eliminated with the removal of a dam, the potential for using other flood control options necessitates an analysis of the Action Alternative dam removal scenario.

Substitution: Since flood control is a basin specific issue, there are no substitution issues other than the shifting of flood danger away from the dam failing catastrophic flood toward the more frequent, but less severe periodic floods.

Dam commissioning vs decommissioning analyses: The anticipated overall effect on flood control would likely be negative for decommissioning studies and positive for commissioning studies. Dam decommissioning studies involve an increase in the probability of the smaller more frequent floods, but an elimination of the potential for the catastrophic dam failing floods. The dam commissioning analysis involves the opposite situation. The expected value of the damages associated with the more frequent smaller floods would probably exceed those of the infrequent catastrophic flood. The analytical approach would be the same for both studies.

3.2.1.7 Land Use/Property Values: Typical Dam Removal BCA Effect: Positive (Benefit Category)

For a federal project, the land under and around the reservoir and dam is owned by the federal government. As a result, there exists the potential that it could be sold after dam removal. The price received for the land sale would reflect the benefit to society given it would presumably represent a measure of the long-term capitalized value of the intended future use of the land. Alternatively, the federal government may choose to keep the land and use it for another purpose, such as a park or wildlife refuge. Forecasted net benefits, or benefits in excess of operating costs, obtained from subsequent use of the federally maintained land should be included in the analysis whenever possible.

Changing residential property values may result from dam removal. Properties closest to the eliminated reservoir would probably be most affected. Even if deemed appropriate to analyze, estimating the potential change in property values with the removal of the reservoir would likely be extremely difficult. For lakeside property owners willing to purchase previously inundated land from the federal government, dam removal would involve the transition from a lake-front to a river-front property. Property owners sometimes suggest that lake-front properties are more valuable than river-front properties, however a study of the AuSable River in Michigan showed the opposite can also be true (Haberman 1995). Lakeside property owners unwilling or unable to purchase previously inundated land would likely experience a decline in property values given they would lose their lake frontage and at best gain a river view. This decline would be especially true if other individuals purchased the previously inundated property thereby blocking access to the river. If the inundated land was not sold, but converted instead into a park or wildlife refuge, the negative impact would likely be less pronounced or even nonexistent. Properties with a view of the lake prior to dam removal would reflect another potentially affected group. Even if values for lake-view versus river-view properties were similar, it is likely that an analysis would identify more lake-view than river-view properties. In other words, certain lake view properties may experience a loss in property values should they not become river view properties after dam removal.

Given impacts to some of the other benefit categories could ultimately manifest themselves in changing property values, adding changes in property value into the BCA could double count impacts. For example, the potential for reduced recreation access with dam removal could adversely affect values of adjacent residential properties. Since lost recreation access would likely be addressed within the recreation analysis, it would be inappropriate to add the recreation and real estate impacts within a BCA. As a result, potential changes in property values are seldom included in a BCA.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

- Sales Price: When land is sold, the sales price would provide a measure of value for private sector benefits.

- Subsequent Federal Benefits: Based on knowledge of the federal government's post dam removal plans, benefits would have to be identified and valued.

- General Methodology and Estimation Techniques:

If dam and reservoir associated lands were to be sold by the federal government, potential uses of the land would have to be evaluated before a reasonable market price could be estimated. Such an analysis would need to take into account many factors including the size of the river's flood plain and local zoning restrictions. Should the land remain in federal government possession, it is likely that a post dam removal management plan would be available. Consulting such a plan would help in identifying and assigning benefits.

Dam commissioning vs decommissioning analyses: The anticipated overall effect on land use would be positive for decommissioning studies (since inundated land is made available) and negative for commissioning studies (since land becomes inundated). This is basically because a decommissioning study would involve the sale of land or creation of a new federal benefit (e.g., wildlife refuge) whereas a commissioning study would involve the purchase of land. There is no net effect for this category since land use issues apply to only a single alternative in each case (i.e., the dam removal action alternative in the dam decommissioning analysis and the No Action/baseline alternative in the dam commissioning analysis). The analytical approach would be similar for both study types.

3.2.2 Nonmarket Based Other Direct Costs/Benefits:

The following other direct cost and benefit categories described in this section reflect goods or services which are not exchanged within a market setting. As a result, estimation is complicated by the lack of price and quantity demanded data. To develop estimates, information is often collected through use of some sort of survey procedure.

3.2.2.1 Recreation: Typical Dam Removal Overall BCA Effect: Varies (Other Direct Cost & Benefit Categories)

Recreation has grown substantially in importance over the past 50 years as populations and leisure time have increased. Despite recreation not being an original project purpose for many dams, federal reservoirs have contributed significantly to the increase in both water based and water influenced recreation activity nationwide.

The effect on recreation of removing a dam is uncertain. While reservoir based activities would obviously be reduced or completely eliminated (i.e., represented as other direct costs or lost benefits under the No Action Alternative), river based activities may increase (i.e., represented by Action Alternative benefits) to the point where overall recreation activity could actually increase. In the short term, the loss of reservoir recreation may outweigh the gain in river recreation. As conditions in the river improve and fish species recover, river recreation gains may exceed reservoir recreation losses. The overall recreation effect cannot be easily predicted and must be addressed case by case.

For ease of presentation, recreation issues are separated into water based activities and land based activities. Recreational fishing is discussed here under the water based recreation activities section as opposed to under the fisheries section primarily because the measurement approaches are similar across all recreation activities.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

‘ Change in Recreator Values are measured in terms of Net Willingness-to-Pay/Consumer Surplus.

‘ Change in Profitability of Commercial Operators

- General Methodology and Estimation Techniques:

The two most common techniques for developing recreator values are travel cost (TC) and contingent valuation (CV).[6] TC modeling makes use of existing information, but may require data collection through onsite surveys. The TC models statistically estimate recreation visitation as a function of the cost of traveling to the site, the quality of the site, and other socioeconomic factors. The model can be used to estimate changes in visitation, with the area under the TC demand curve and above price providing an estimate of recreator value or consumer surplus. The CV approach is based on data obtained from onsite or general population surveys. Specific questions are asked to evaluate potential changes in recreator visitation and value in response to the dam removal scenario. The results of the CV surveys can be used to estimate changes in

[6] A third approach, involves using standard unit day values by recreation activity applied to estimates of visitation change by activity. Unit day values were originally based on studies of entrance fees conducted in the early 1960s, the values have subsequently been indexed up to current dollars. To apply the values, the analyst must have estimated changes in visitation by some other approach. While unit day values are authorized for use in the P&Gs, in practice, they are seldom used since they are based on dated information with questionable theoretical basis.

visitation and value directly (i.e., average the survey responses) or may be used to develop models to estimate such changes.

A popular option to gathering data and developing TC or CV models involves benefits transfer. Benefits transfer makes use of past research to estimate current values. Frequently, benefits transfer may be the only option given data, time, and budget constraints prevent modeling.

> Under the best conditions, previously developed statistical models for the original study site are used to estimate visitation and value at the site of current interest, normally referred to as the policy site. Care must go into selection of the most appropriate model for transfer based on similarities between the study and policy sites in terms of site and population characteristics. The statistical coefficients of the study site model are used in conjunction with policy site information to predict visitation and value at the policy site.
>
> Another somewhat more controversial benefit transfer approach applies meta analysis models to estimate recreation values by activity and geographic region (Rosenberger and Loomis, 2001). Benefit estimates from a wide range of recreation studies are indexed to a common year and used as the meta model's dependent variable. Study characteristics such as geographic area, recreation activity, fish or wildlife species, change in site quality, and numerous study specific sampling and statistical modeling characteristics are used to explain the variation in benefit estimates. The model's coefficients for different regions, activities, and species can be used to estimate recreation values.
>
> While typically dismissed in the literature as not being technically sufficient, oftentimes values per trip from the original study are simply transferred to the policy site after indexing to current dollars. With both this approach and the meta analysis approach, estimates of changes in visitation would need to be developed to combine with the value transfer. If sufficient historical data exists on visitation and instream flows and/or fish populations/harvest, use estimation models could be attempted. Such models estimate the relationship between visitation and site quality variables and can be used to predict visitation associated with changes in those variables. Depending on the required accuracy of the valuation estimates, great care may be necessary when making benefit transfers.

Stated simply, the recreation analyses evaluate changes in recreation trips and value per trip by activity across the range of affected sites (i.e., reservoirs, rivers, oceans). Aggregating total recreation value across all affected sites both with and without the dam allows for estimation of the overall recreation effect.

3.2.2.1.1 **Water Based Activities**:

> Recreational activities dependent upon water would logically be most directly impacted by removal of a dam. Depending on the location of the dam and the river system, recreational effects of dam removal could affect flatwater reservoir based recreation

(fishing, boating, swimming, etc.), in-river recreation (fishing, boating, rafting, etc.), and perhaps even ocean recreational fishing should anadromous fisheries be involved.

As noted above, recreation modeling options all typically use site quality variables to model visitation and value. As a result, changes in instream flows and/or fish populations/harvest between with and without dam scenarios could be used to evaluate changes in river and ocean based recreation visitation and value by activity. Both of these site quality variables would be especially appropriate for recreational fishing analyses, whereas perhaps the instream flow variable would be most relevant for the non-fishing activities. Due to the potential for catch and release fishing, T&E fish species can generate use values (in addition to the nonuse values discussed in the next section) despite harvest restrictions. With dam removal, it is typically safe to assume that reservoir activities would be completely lost. When data is limiting, direct surveys of recreators may be necessary to estimate changes in visitation and value.

3.2.2.1.2 **Land Based Activities**:

Water based recreational activities would obviously be directly impacted by dam removal, but it is also possible that land based activities could be significantly affected. Land based recreation includes both nonconsumptive activities such as camping, picnicking, hiking, sightseeing, and wildlife watching as well as consumptive activities, primarily hunting. While water access is not necessary to pursue land based activities, the presence of water may enhance these activities. Relationships between the presence and quantity of water and land based visitation often proves statistically significant. Therefore, the same models relevant to water based activities could be attempted for land based activities. Surveys would likely be needed to determine if land based activities would transition from a reservoir setting to a river setting. Obviously, for this to happen, certain recreational facilities would have to be relocated or constructed (e.g., campsites, picnic tables, hiking trails).

1) Consumptive (hunting):

As with the fisheries analysis, removal of the dam and reservoir may have an effect on wildlife populations. Wildlife biologists would need to estimate changes in species specific wildlife populations prior to any economic analysis. Once the wildlife populations have been estimated, harvest would be estimated and valued.

2) Nonconsumptive (wildlife watching, sightseeing, picnicking, hiking, camping, etc.)

Like the fishing and hunting analyses, the analysis of wildlife watching would also be dependent upon population estimates developed by biologists. Depending on the species, wildlife populations could conceivably either increase or decrease with dam removal. Since the wildlife populations are not harvested under these activities, population levels should directly affect visitation. For many wildlife watchers, the larger the wildlife population, the better the experience. However, in certain circumstances, viewing a rare and endangered species could be the primary attraction. Therefore, while it is often assumed that wildlife watching activity increases as populations increase, in some cases the reverse may be true.

Of particular importance in a dam removal study may be the impact upon aesthetics. This is an extremely difficult issue to address. The conversion of an area from a reservoir to a free flowing river setting may be seen by some as an improvement and by others as a detraction. The aesthetic value before dam removal would obviously be affected by reservoir operations, the more a reservoir fluctuates, the greater the potential for unsightly mud flats and reservoir rings. Similarly, excessive sediment and rock discoloration could affect recreation use after a dam is removed. However, given time, nature will heal itself. For example, based on side canyon evidence at Lake Powell, sediments were flushed within a couple of years and white "rings" disappeared in 5 to 10 years (Miller, 2000). Estimates of sightseeing visitation before and after dam removal may address this issue. However, sightseeing visitation could also be affected by the degree of access. Visitation associated with the other land based activities such as picnicking, hiking, and camping could also be influenced by the scenic quality of the site. Instream flow/reservoir water level may be a useful site quality indicator for these activities.

While typically not a large component of recreation value, in some circumstances, changes in commercial operator (e.g., guide boat) profitability may need to be evaluated under the Action and No Action/baseline alternatives. Changes in recreation visitation at a site may be significant enough to warrant a review of both recreator value and commercial operator profitability. This is contrary to many of the market based approaches where analyses are limited to changes in profitability at the harvest/manufacturing level under the standard assumption that the changes in output would not be significant enough to affect prices. To estimate changes in commercial operator profitability, estimates of the number of clients under each alternative would be applied to information on prices and variable costs. Losses in reservoir operator profitability would be compared to gains in river and perhaps ocean operator profitability.

Substitution: Recreation substitution may take several different forms including site, activity, and species substitution. While the discussion below uses examples with water based activities, the concepts apply to land based activities as well.

1) Site substitution involves the movement of recreators between different sites as conditions change. With dam removal, given the reservoir is lost, recreators interested in flatwater recreation may decide to move to other lakes and reservoirs in the region.

2) Activity substitution involves the movement of recreators between different activities at the same site as conditions change. As noted above, with dam removal, recreators may simply

switch from flatwater activities to in-river activities. While the recreators may decide to pursue the same general activity, say motorized boating, the change from reservoir to river essentially implies a different type of boating experience in each case.

3) Species substitution involves the movement of recreators between target species at the same site as conditions and species populations change. The activity remains the same but the species sought changes. Species substitution typically pertains to fishing and hunting activities. With dam removal, the mix of species is likely to change especially with regard to fishing. In other words, the types of fish species resident in the reservoir may be different from those found in the river. Some recreators may decide to switch from reservoir fishing to river fishing as in-river fish populations improve.

Additionally, the species mix found in the river may actually change with dam removal. In certain of the West's warm water rivers, releasing cold water from dams has provided habitat for cold water fisheries for several miles downstream of the dam. At Glen Canyon and Flaming Gorge dams, these downstream areas have been stocked with trout creating valuable recreational fisheries. Dam removal would eliminate the cold water fishery in lieu of an improved warm water fishery. Conversely, in cold water rivers, drawing from the top of the reservoir has actually warmed the water compared to pre-dam conditions, thereby reducing the populations of native cold water salmon and steelhead. In this case, dam removal could increase cold water habitat, thereby returning cold water species into areas previously too warm for their survival.

Species substitution could also be relevant for the ocean recreational fishing analysis. To the extent that increased populations of anadromous fish are caught recreationally in the ocean, consideration may need to be given to whether those anglers targeting these fish may have switched from other ocean species.

Typically, the only way to deal with recreation substitution is by conducting surveys of current and potential recreators. Surveys would need to describe the setting with and without the dam, including gains for river fisheries compared to losses for reservoir fisheries. Based upon this information, recreators would be asked to estimate their visitation and value per trip under both Action and No Action/baseline alternatives.

Dam commissioning vs decommissioning analyses: The anticipated effect on recreation would be unknown for both decommissioning and commissioning studies. The direction of the effect depends on the degree of substitution of the recreation activity. With dam decommissioning studies, flat water reservoir recreation would be lost, but in river recreation would increase. In addition, flat water recreation at other regional reservoirs may also increase. The opposite would be true of dam commissioning studies.

3.2.2.2 Nonuse Values: Typical Dam Removal Overall BCA Effect: Positive (Benefit Category)

Nonuse, intrinsic, or passive use values, reflect an individual's willingness-to-pay for a unique resource even if they never intend to physically use it. With dam removal, people may be willing to pay for returning a river to a more free flowing state. If threatened and endangered (T&E) species are involved, people may be willing-to-pay to ensure preservation of those species. Dam removal is typically expected to help improve damaged habitats thereby aiding in the recovery of dependent T&E species. Oftentimes, nonuse values are one of the primary benefit components associated with dam removal. These resource existence values have been validated through research studies and actual experience where society has been willing to pay to preserve remote national resources such as the Alaskan National Wildlife Refuge. A very small percentage of the general population will ever actually visit the refuge, yet environmental organizations have been able to collect substantial donations for programs which push for preservation.

The components of nonuse value generally fall into three primary categories: existence value, option value, and bequest value. Existence value is derived from the satisfaction of knowing that a particular resource/habitat/species exists even if no onsite use is ever expected. Option value reflects satisfaction associated with maintaining a resource for some future use, including recreational, medicinal, and other purposes. Some claim that option value simply reflects future use values under uncertainty and therefore do not reflect true nonuse values. Bequest values reflect satisfaction individuals receive from knowing a resource will be preserved for future generations.

Benefit-Cost Analysis Issues:

- Practical Measurement Approaches:

‘ Total Societal Willingness-to-Pay:

The only currently available approach for estimating nonuse value total WTP is to conduct general population contingent valuation surveys. Extreme acre must go into defining the potentially affected population, constructing the questionnaires, and implementing the survey.

Benefit transfer approaches, as described under the recreation section, may be possible for nonuse valuation under very limited conditions. Since nonuse values are generally estimated by averaging and summing survey results, benefits transfer would normally involve applying values as opposed to models, from the original study to the policy application. Extreme care must go into determining if the details of the original study align well with those of the application. For a T&E species situation, the same or similar fish/wildlife/plant species[7] would need to be affected to a similar degree for nonuse values to be transferrable. Loomis and White (1996) suggest that meta analysis equations for similar species might be applicable at some point to provide rough nonuse value estimates for benefit-cost analysis. Despite the probability of being less accurate than an original nonuse value study, meta equation estimates might be sufficient for providing "ballpark" estimates. In situations where a dam removal study's benefits and costs are reasonably close, an original nonuse value study may be necessary to obtain greater accuracy. Bottomline, using benefits transfer for nonuse valuations may be a questionable practice. Nonuse valuation is fraught with numerous difficulties and considerable suspicion when done carefully as an original research project. To try and apply a benefits transfer approach, which has numerous critics of its own, to the already controversial area of nonuse valuation may significantly amplify the public's uneasiness with the results.

Nonuse values should be used with caution. Given that nonuse values are necessarily based on our current understanding of a particular resource, to the extent that our knowledge is insufficient and underestimates the importance of a resource, the associated nonuse value measure would also be underestimated. Care must go into the aggregation of nonuse values, taking into account the duration of the value estimates and the size of the affected population. Given preservation has implications for future generations, it is likely that most nonuse values, although typically large, may only reflect a lower bound. Since extinction is permanent, a prudent position may be to take a conservative stance by preserving resources at levels sufficient to ensure long-term survival. A similar position often espoused by the environmental community is that nonuse values for T&E species are infinite. Under that assumption, the decision has already been made that something must be done to preserve the species. As a result, the analysis converts from a benefit-cost comparison (should something be done?) to a cost-effectiveness comparison (what should be done?). With cost-effectiveness analysis (CEA) the decision focuses on the least cost method of preserving the species. Taking the position that ESA implies the federal government is legally bound to preserve T&E species gets to the same point of needing to conduct CEA as opposed to a BCA.

- General Methodology and Estimation Techniques:

Loomis (1996) conducted a nationwide survey of households to determine if they would be willing-to-pay to remove two salmon migration blocking dams on the Elwha River in the Olympic Peninsula of Washington state. The results indicated that local county, Washington

[7] While virtually all species oriented nonuse value studies to date have involved a fish or wildlife species, the same nonuse approaches could theoretically be applied to plant species. Loomis and White (1996) suggest that as the T&E lists continue to expand, that instead of focusing on individual species, the orientation of future preservation efforts will likely be on entire ecosystems.

State, and U. S. residents were all willing-to-pay to remove the dams. When aggregating across the relevant number of households, annual values ranged from $94-138 million in Washington State to $3.5 - 6.3 billion nationwide. It was interesting to note that local county residents were willing-to-pay less on average than both statewide and nationwide residents.

Nonuse values may or may not be relevant for a given resource. The assumption is normally made that the resource must be unique and of national significance before nonuse values exist. However, it appears possible that the resource could be of regional, but not national significance, and still generate nonuse values but of a regional nature. Huppert (1999) suggests that care must be used when aggregating nonuse values. Referring to the Loomis (1996) nonuse value study, Huppert notes that the general public outside the Pacific Northwest may not sufficiently understand the technical nature of the public good referred to in the Elwha study to allow for nationwide aggregation. Despite the controversy over the degree of aggregation and other estimation issues, in theory, the existence of nonuse values is generally well accepted by the economics community. In many environmental enhancement studies, the nonuse value element reflects the largest benefit component.

Another issue requiring resolution is the potential linkage between nonuse values and use values (recreational, commercial, tribal) when endangered species are involved. Assuming the intent of the proposed action is to help recover the listed species, the question becomes would the species actually recover under the proposed action? If so, when would this recovery occur and at what population level would the species be assumed recovered. Presumably, upon reaching the point of recovery, the species would then be available for harvest. Another question would relate to whether or not existence values would continue after a species has fully recovered. It may be that nonuse values drop significantly with species recovery, perhaps to zero. If this is the case, then values would shift from nonuse to use around the point of recovery. Given nonuse values are spread across all regional or national households, whereas use values pertain to users only, it is possible that the sum of both nonuse and use values may actually decline with recovery of the species (i.e., total value of the species may be greater when they were listed (nonuse value only) as compared to their recovered value (use value only)). The extreme case would be the shifting of values from nonuse to use for species with no commercial, recreational, or tribal significance. When listed, such a species may have nonuse value, but after recovery, such a species may have little to no harvest value. Much of this discussion centers on the definition of recovery. For example, if a T&E fish species within a given river system recovers to the point of achieving a long-term sustainable population, the species may be removed from the T&E list, but may still be considered unique in that it could only be found in that river system. In this case, nonuse values may still apply. However, if the T&E fish species recovers and expands its range to include sustainable populations within a series of river systems, that species may no longer be considered unique and nonuse values may no longer apply.

Dam commissioning vs decommissioning analyses: The anticipated effect on nonuse valuation would likely be positive for decommissioning and negative for commissioning studies. Society values the presence of free flowing rivers and the preservation of endangered species often associated with dam decommissioning. The opposite would be true of dam commissioning studies. There is no net effect for this category since nonuse issues apply to only a single alternative in each case (i.e., the dam removal action alternative in the dam decommissioning analysis and the No Action/baseline alternative in the dam commissioning analysis). The analytical approach would be the same for both studies.

3.3 **HYPOTHETICAL DAM REMOVAL EXAMPLE**:

The hypothetical example presented below represents a dam removal benefit-cost analysis framework using both approaches of estimating effects separately for each alternative (action alternative = dam removal, no action alternative = keep dam) and combining the effects within an incremental analysis from the perspective of dam removal.

While this example includes most of the categories of impact referred to above in Table 1, not all of the range of categories apply. For example, the costs of maintaining the site under the dam removal alternative does not apply since the assumption was made that the land was sold as opposed to being managed by the federal government.

3.3.1: Dam Removal (Action) Alternative:

The hypothetical dam removal scenario is assumed to include the following elements:

a) Direct Implementation Costs:
- complete removal of the dam and structures
- installation of pumps to draw water from the river for agriculture and M&I
- construction of levees to provide flood control
- sediment dredging and removal
- site stabilization and restoration

b) Benefits:
- commercial fishing (tribal and non-tribal)
- agriculture due to river pumping
- M&I due to river pumping
- hydropower is completely lost, but replacement power is available
- navigation is completely lost, but alternative transit modes are available
- flood control benefits due to levees
- value of inundated land based on selling price
- river recreation

- nonuse values associated with recovery of endangered species

3.3.2: <u>Keep Dam (No Action) Alternative</u>:

The hypothetical keep dam scenario is assumed to include the following elements:

a) Direct Implementation Costs:
- extensive rehabilitation of the existing dam to maintain structural stability
- in river habitat improvement to slow the current fisheries decline
- long-term dam operations and maintenance costs

b) Benefits:
- commercial fishing
- agriculture
- M&I
- hydropower
- navigation
- flood control
- river and reservoir recreation
- zero nonuse values (endangered species are assumed to become extinct)

3.3.3: <u>Benefit Costs Analysis (BCA)</u>:

Table 3 presents the results of a hypothetical BCA using the above assumptions for each alternative. The numbers are purely fictional and are used for illustrative purposes only.

In Table 3, the far left column lists the various impact categories associated with each alternative under two general headings: 1) direct implementation costs or avoided cost benefits and 2) benefits or other direct costs. Under the "Dam Removal" Action Alternative (column 1) and "Keep Dam" No Action Alternative (column 2), net benefits are calculated for each alternative by deducting the costs from the benefits. Note that both alternatives result in positive net benefits, 75 million for the dam removal alternative and 40 million for the no action alternative. Based on this information, the dam removal alternative would be selected since it results in greater net benefits.

Under the "Dam Removal Alternative Incremental Analysis" (column 3) the costs and benefits for both alternatives are combined from the perspective of dam removal. The benefits and costs of the dam removal alternative are presented as in column 1. The costs and benefits of the no action alternative are presented oppositely as compared to column 2. In other words, the direct costs associated with the no action alternative are presented as avoided cost benefits from the perspective of the dam removal action alternative. Similarly, the benefits of the no action alternative are presented as other direct costs (lost benefits) from the perspective of the dam removal action alternative. Again, the net benefits are calculated by deducting the direct implementation costs and other direct costs from the benefits of avoided costs. The 35 million in positive net benefits implies that the dam removal alternative would be selected over the no action alternative. If the incremental analysis had resulted in a negative figure, the no action alternative would have been preferred. Note that the net benefits which result from the incremental analysis exactly equal the difference in net benefits with the separate alternative analysis (75 minus 40 million).

Table 3: Benefit-Cost Analysis of Hypothetical Dam Removal Example								
Impact Category	**"Dam Removal" Action Alternative (1)**		**"Keep Dam" No Action Alternative (2)**		**Dam Removal Alternative Incremental Analysis (3)**			
(Long-term Cost or Benefit streams would need to be converted to a present value (PV))	**Direct Implementation Costs**	**Benefits**	**Direct Implementation Costs**	**Benefits**	**Direct Implementation Costs**	**Other Direct Costs (Lost Benefits)**	**Benefits or Avoided Costs**	**Net Effect**
1) ***Direct Implementation Costs or Avoided Cost Benefits*** (Millions $): +#, = negative number								
Dam Removal	+25,				+25,			-25
Pumps	+5,				+5,			-5
Flood Control Levees	+10,				+10,			-10
Rehabilitate Dam			+50,				50	+50
Sediment Removal	+10,				+10,			-10
Site Stabilization and Restoration	+10,				+10,			-10
PV of Long-term River Habitat Improvement			+5,				5	+5
PV of Long-term Dam Operations and Maintenance			+10,				10	+10
2) ***Benefits or Other Direct Costs*** (Millions $):								
PV of Long-term Commercial Fishing		15		5		+5,	15	+10
PV of Long-term Agriculture		10		25		+25,	10	-15
PV of Long-term M&I		10		20		+20,	10	-10
PV of Long-term Hydropower		10		15		+15,	10	-5
PV of Long-term Navigation		10		15		+15,	10	-5
PV of Long-term Avoided Flood Damages		10		15		+15,	10	-5
Selling Price of Inundated Land		5					5	+5
PV of Long-term River & Reservoir Recreation		15		10		+10,	15	+5
Nonuse Values		50					50	+50
Total:	+60,	135	+65,	105	+60,	+105,	200	+35
Net Benefits:		+75		+40			+35	

4.0 SUMMARY & CONCLUSIONS

Dam decommissioning analyses are becoming more commonplace as structures age and dams are increasingly targeted as a cause of environmental problems. As a result, it is important to describe the range of analyses necessary to provide a comprehensive benefit-cost review of the broad spectrum of effects associated with dam removal. While this paper focuses on the economic aspects of benefit-cost analysis (BCA), it should be noted that a comprehensive BCA incorporates qualitative discussions of impacts which cannot be quantified or measured in dollar terms. BCA has its critics, but the implicit assumption has been made that the approach provides useful information for the decision process.

This paper presents economic effects which may need to be addressed including both market and non-market based components. In addition to the traditional market based impacts to agriculture, hydropower, flood control, and navigation, other potential market oriented components may also need to be considered including commercial fishing, tribal fishing, and municipal and industrial uses. Nonmarket based impacts to recreation and nonuse valuation could also be critical to the analysis. Finally, the range of direct implementation costs can be extensive, including such cost elements as dam and sediment removal, site stabilization and restoration, and long-term maintenance.

Despite the fact that there may be some differences in the analytical approaches used to measure impacts, as well as in the range of impacts considered in each analysis, for the most part, the analyses of dam decommissioning versus dam commissioning are fairly similar, more or less reflecting mirror images of each other. From a direct implementation cost perspective, with dam commissioning one must include the costs of dam construction and long-term operations and maintenance. With dam decommissioning, the costs of dam removal and long-term maintenance are important. In addition, other costs may come into play with dam decommissioning including sediment removal, site stabilization, and restoration. With dam commissioning, benefits often are expected to accrue to agriculture, M&I, hydropower, navigation, and flood control. With dam decommissioning, even after taking into account substitution effects, these benefit categories are expected to be reduced or eliminated. With dam commissioning, fisheries are often considered adversely affected despite the creation of a resident reservoir fishery. With dam decommissioning, native fisheries are expected to gradually recover over time. The overall recreation effect may vary under both dam commissioning and dam decommissioning scenarios due to the influence of substitution. Most dam commissioning analyses either did not evaluate recreation or show a positive recreation effect. However, the positive recreation effect may have been the result of not taking into account substitution. With dam decommissioning, one of the major substitution effects which needs to be addressed in the recreation analysis is to what extent reservoir recreation would convert to river recreation. Finally, due to their relatively recent development, nonuse values were not addressed in dam commissioning analyses, but dam construction would likely generate negative nonuse values. Conversely, nonuse values often represent a significant benefit within dam decommissioning analyses. Many of these differences between the impact components included in the dam commissioning versus the dam decommissioning analyses are the result of implementation of both NEPA and the P&Gs. If both a dam decommissioning and dam commissioning analyses were conducted today using the guidance included in NEPA and the P&Gs, the two analyses would likely be similar but inverse.

Developing a comprehensive benefit-cost analysis of dam removal can be a daunting task given the broad range of economic effects associated with the presence of a large scale dam. Despite the difficulties in measuring costs and benefits, assuming the study addresses the majority of significant impacts, the benefit-cost comparison could provide a methodology for objectively evaluating the dam decommissioning proposal from a nationwide perspective.

Approaching economic effects from a national benefit-cost perspective obviously makes sense for proposals concerning federal government facilities. Nevertheless, other perspectives, not addressed in this document, may also be of interest to the federal decision maker, including the following:

1) Regional Economic Impact Analysis:

Federally oriented BCA takes into consideration economic effects nationwide. Given this perspective, local or regional economic effects are sometimes offset by effects elsewhere in the nation. While nationwide effects reflect the proper viewpoint for a federal government action, federal decision makers may also be interested in understanding the effect upon the local economy where a significant percentage of the impacts may occur. For example, if dam removal would have a devastating effect upon a given industry within a region heavily dependent on that industry, federal decision makers would likely be interested so as to try and develop possible mitigation programs. In addition, regional economic impact analyses may provide a broader range of impacts than a BCA by taking into account regional intra-industry (i.e., industry manufacturing/harvest, processing, wholesale, retail components) and inter-industry (i.e., across industry effects via substitution/complementary goods) linkages. For larger regions, general equilibrium models may be necessary to account for not only substitution/complementary effects, but also price changes. Local government officials are normally especially interested in regional impacts, particularly employment effects. So while the national perspective may drive the overall decision, regional effects may also be of considerable interest.

2) Financial Analysis:

A financial analysis of dam decommissioning would look at the effects of removing a federal dam upon the U. S. Treasury. The direct implementation costs of dam decommissioning would be included in the analysis as well as the potential effects on project repayment and other sources of federal government income (e.g., hydropower revenues). A financial analysis would not include certain benefits and other direct costs which have no bearing on the cash flow of the federal government (e.g., recreation and nonuse values).

5.0 BIBLIOGRAPHY

American Rivers, Friends of the Earth, and Trout Unlimited. Dam Removal Success Stories - Restoring River Through Selective Removal of Dams that Don't Make Sense. Washington, D.C.: Trout Unlimited. December 1999. 115 pages. ISBN0-913890-96-0.

Blumm, M., L. Lucas, D. Miller, D. Rohlf, and G. Spain. 1998. Saving Snake River water and salmon simultaneously: The biological, economic, and legal case for breaching the Lower Snake River dams, lowering John Day Reservoir, and restoring natural river flows. *Environmental Law* 28(4):997-1054.

Born, S., K. Genskow, T. Filbert, N. Hernandez-Mora, M. Keefer, and K. White. 1998. Socioeconomic and institutional dimensions of dam removals: The Wisconsin experience. *Environmental Management* 22(3):359-370.

Boyle, K. 1991. Economic benefits accruing to sport fisheries on the lower Kennebec River from the provision of fish passage at Edwards Dam or from the removal of Edwards Dam. Department of Marine Resources, Augusta ME, 104p.

Bryant, Beth C. 1999. "FERC's Dam Decommissioning Authority under the Federal Power Act." *Washington Law Review*. 75(1):95-125.

DeLong, J. 1998. Dam Fools. *Reason* (April):40-47.

Department of Interior, National Park Service. 1995. Elwha River ecosystem restoration implementation, Olympic National Park, Clallam County, Washington. Final EIS.

Department of Interior, Department of Commerce, Lower Elwha S'Klallam Tribe. 1994. Restoration of the Elwha River Ecosystem and Native Anadromous Fisheries, Appendices E - M. Report submitted pursuant to Public Law 102-495.

Department of Interior, Bureau of Reclamation. 1995. Elwha River Restoration Project, Washington, Regional Economic and Tax Revenue Impact Analysis. Elwha technical series PN-95-2.

Federal Energy Regulatory Commission. 1994. Project Decommissioning at Relicensing: Policy Statement. RM93-23-000. 60 Federal Register 339 (January 1995). III FERC Stats. & Regs. 31,001 at p. 31,001. December 14, 1994.

General Accounting Office. 1991. Hydroelectric dams: Costs and alternatives for restoring fisheries in the Elwha River. Report # GAO/RCED-91-104.

Huppert, D. 1999. "Snake River Salmon Recovery: Quantifying the Costs." *Contemporary Economic Policy* 17(4):476-491.

IUCN - The World Conservation Union and the World Bank Group. July 1997. *Large Dams: Learning from the Past, Looking at the Future. Workshop Proceedings*. IUCN, Gland, Switzerland and Cambridge, UK and the World Bank Group, Washington, DC. V. +145 pp.

Just, R. E. and D. L. Hueth. December 1979. "Welfare measures in a multimarket framework." *American Economic Review* 69(5):947-954.

Just, R. E., D. L. Hueth, and A. Schmitz. 1982. "Applied welfare economics and public policy". Prentice-Hall, Inc., Englewood Cliff, NJ.

Larmer, P. 1999. Unleashing the Snake. *High Country News* (December 20).

Loomis, J. 2002. Quantifying recreation use values from removing dams and restoring free-flowing rivers: A contingent behavior travel cost demand model for the Lower Snake River. *Water Resources Research* 38(6):2-1 through 7.

Loomis, J. 1997. Use of non-market valuation studies in water resource management assessments. *Water Resources Update* 109(August):5-9.

Loomis, J. 1996. Measuring the economic benefits of removing dams and restoring the Elwha River: Results of a contingent valuation survey. *Water Resources Research* 32(2):441-447.

Loomis, J. and M. Feldman. 1995. An economic approach to giving "equal consideration" to environmental values in FERC hydropower relicensing. *Rivers* 5(2):96-108.

Loomis, J. and D. White. 1996. Economic benefits of rare and endangered species: summary and meta-analysis. *Ecological Economics* 18:197-206.

Marcus, D. and K. Garrison. Going with the Flow - Replacing Energy from Four Snake River Dams. Natural Resources Defense Council and the Northwest Energy Coalition. April 2000. 49 pages.

Meyer, P., R. Lichtkoppler, R. Hamilton, C. Borda, D. Harpman, and P. Engel. 1995. Elwha River Restoration Project: Economic Analysis. A report to the U. S. Bureau of Reclamation, the National Parks Service, and the Lower Elwha S'Klallam Tribe. Davis, CA.

Miller, S. K. 2000. "Undamming Glen Canyon: Lunacy, Rationality, or Prophecy?" *Stanford Environmental Law Journal*. vol. 19: pgs 121-207.

Morlan, T. 1999. "A note on the role of economics in Pacific Northwest salmon policy." *Northwest Journal of Business and Economics*.

Moxon, S. 1999. Save our dams. *International Water Power and Dam Construction* 51(4) 27-8.

Piper, S. 2000. Estimating Regional Economic Impacts in an Economic Analysis. Technical Memorandum # EC-2000-04, Bureau of Reclamation, Technical Service Center, Denver CO.

Reynolds, P. 1995. Barrage of Fire. *International Water Power and Dam Construction*. 47(3) 52-3.

Rosenkrans, S. The Effect of Draining Lake Powell on Water Supply and Electricity Production. Unpublished report. Environmental Defense Fund, Oakland, CA. September 1997.

Shuman, J. 1995. Environmental considerations for assessing dam removal alternatives for river restoration. *Regulated Rivers: Research and Management* 11: 249-261.

Task Committee on Guidelines for Retirement of Dams and Hydroelectric Facilities. 1997. Guidelines for Retirement of Dams and Hydroelectric Facilities. Committee of the Energy Division of the American Society of Civil Engineers. New York, NY. 222 pages.

Wade, B. 1999. Bringing down the dams. *American City & County* 114(6):20.

Wade, B. 1999. Finances vs. fish: A dam-nable debate. *American City & County* 114(6):28.

U. S. Water Resources Council. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." U. S. Government Printing Office, Washington D. C.

World Commission on Dams. 2000. "Dams and Development: A New Framework for Decision Making: Overview." website location: www.dams.org.

RECLAMATION'S MISSION

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

DEPARTMENT OF THE INTERIOR'S MISSION

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering wise use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. Administration.